GEOLOGICAL SURVEY OF CANADA
BULLETIN 431

STRATIGRAPHY, SEDIMENTOLOGY, COAL GEOLOGY AND DEPOSITIONAL ENVIRONMENTS OF THE LOWER CRETACEOUS GETHING FORMATION, NORTHEASTERN BRITISH COLUMBIA AND WEST-CENTRAL ALBERTA

D.W. Gibson

With Contributions by

J.H. Wall
J.A. Jeletzky
D.J. McIntyre

1992

Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada

Canada

THE ENERGY OF OUR RESOURCES

THE POWER OF OUR IDEAS

GEOLOGICAL SURVEY OF CANADA
BULLETIN 431

STRATIGRAPHY, SEDIMENTOLOGY, COAL GEOLOGY AND DEPOSITIONAL ENVIRONMENTS OF THE LOWER CRETACEOUS GETHING FORMATION, NORTHEASTERN BRITISH COLUMBIA AND WEST-CENTRAL ALBERTA

D.W. Gibson

With Contributions by

J.H. Wall
J.A. Jeletzky
D.J. McIntyre

1992

93-01821/

©Minister of Supply and Services Canada 1992

Available in Canada through authorized
bookstore agents and other bookstores

or by mail from

Canada Communication Group – Publishing
Ottawa, Ontario K1A 0S9

and from

Geological Survey of Canada offices:

601 Booth Street
Ottawa, Ontario K1A 0E8

3303 - 33rd Street N.W.
Calgary, Alberta T2L 2A7

100 West Pender Street
Vancouver, B.C. V6B 1R8

A deposit copy of this publication is also available
for reference in public libraries across Canada

Cat. No. M42-431E
ISBN 0-660-14236-8

Price subject to change without notice

Critical readers

D.A. Leckie
D.F. Stott

Scientific editor

N.C. Ollerenshaw

Typesetting and layout

M.L. Jacobs
P.L. Greener

Cartography unit

Institute of Sedimentary and Petroleum Geology

Author's address

Institute of Sedimentary and Petroleum Geology
Geological Survey of Canada
3303 - 33rd Street N.W.
Calgary, Alberta T2L 2A7

Manuscript submitted: 87.11.16
Approved for publication: 87.12.23

PREFACE

The Gething Formation in northeastern British Columbia has long been of economic interest as a potential source of thermal and metallurgical coal. This report, which is based on field observations and much recently acquired data from subsurface coal exploration, describes the geology of the Gething Formation on a regional basis, and provides detailed information and data on lithofacies, lithofacies relationships, age and correlation of important lithostratigraphic marker units, the distribution of coal seams, and the depositional setting.

Elkanah A. Babcock
Assistant Deputy Minister
Geological Survey of Canada

PRÉFACE

La formation de Gething, dans le nord-est de la Colombie-Britannique, revêt depuis longtemps une certaine importance économique en tant que source possible de charbon thermique et métallurgique. Le présent rapport, fondé sur des observations sur le terrain ainsi que sur des données acquises récemment dans le cadre de projets d'exploration du charbon en profondeur, décrit la géologie de la formation de Gething à l'échelle régionale. Il fournit aussi des données ainsi que des renseignements détaillés sur les lithofaciès et les liens entre chacun, sur l'âge et la corrélation d'unités lithostratigraphiques repères importantes, sur la répartition des filons houillers ainsi que sur le milieu de sédimentation.

Elkanah A. Babcock
Sous-ministre adjoint
Commission géologique du Canada

CONTENTS

1 Abstract/Résumé
2 Introduction
2 Previous work
3 Acknowledgments
6 Stratigraphy of the Gething Formation
6 Introduction
7 Nomenclature and formation definition
9 Lithology, thickness and age relationships
11 Gaylard Member
11 Definition, distribution and thickness
14 Lithology
14 Conglomerate and conglomeratic sandstone
15 Sandstone
16 Siltstone
18 Mudstone
18 Claystone-tonstein
19 Sandstone-siltstone-mudstone facies assemblage
20 Miscellaneous facies
21 Facies variations
22 Contact relationships
25 Age and correlation
26 Sedimentary and biogenic structures
30 Bullmoose Member
30 Definition, distribution and thickness
33 Lithology
33 Rhythmic sandstone-siltstone-mudstone facies assemblage
34 Sandstone
34 Facies variations
34 Contact relationships
35 Age and correlation
36 Sedimentary and biogenic structures
36 Chamberlain Member
36 Definition, distribution and thickness
39 Lithology
39 Fine to coarse grained sandstone
41 Conglomerate to conglomeratic sandstone
41 Sandstone-siltstone-mudstone facies assemblage
41 Siltstone-mudstone
44 Facies variations
44 Contact relationships
47 Age and correlation
47 Sedimentary and biogenic structures
50 Occurrence and distribution of coal in the Gething Formation
51 Gaylard Member
54 Bullmoose Member
54 Chamberlain Member
55 Undifferentiated Gething Formation
56 Paleoenvironments and history of deposition
56 Introduction
58 Gaylard Member
63 Bullmoose Member
65 Chamberlain Member

68 Economic Geology
68 Coal
68 Gaylard Member
69 Bullmoose Member
69 Chamberlain Member
69 Undifferentiated Gething Formation
69 Oil and gas
70 References
79 Appendix 1 (Section and well data)
79 A. Field sections
80 B. Coal exploration boreholes
82 C. Petroleum exploration wells
83 Appendix 2 (Paleontology)
83 A. Micropaleontology (J.H. Wall)
112 B. Macrofossils (J.A. Jeletzky)
113 C. Palynology (D.J. McIntyre)
118 Appendix 3 (Type and reference sections)
118 A. Bullmoose Member (type); Gaylard and Chamberlain members (reference)
125 B. Chamberlain Member (type)

Illustrations

Figures

4 1a. Index map
5 1b. Locations and names of field sections and boreholes
6 2. Nomenclature chart and subdivisions of the Gething Formation
in pocket 3. Columnar sections, Gething and Gladstone formations, Narraway and Smoky rivers
in pocket 4. Columnar sections, Gething Formation, Belcourt River area
in pocket 5a. Columnar sections, Gething Formation, Five Cabin Creek and Dokken Creek area
in pocket 5b. Columnar sections, Gething Formation, Quintette Mountain and Wapiti River area
in pocket 6. Columnar sections, Gething Formation, Burnt-Sukunka rivers area
in pocket 7. Columnar sections, Gething Formation between the Hasler – Brazion creeks and Burnt-Sukunka rivers areas
in pocket 8. Columnar sections, Gething Formation, Hasler – Brazion creeks area
in pocket 9. Columnar sections, Gething Formation, Peace River Canyon area
in pocket 10a. Columnar sections, Gething Formation, between Pink Mountain and the British Columbia-Alberta border
in pocket 10b. Columnar sections, Gething Formation between Smoky River and Pink Mountain
10 11. Isopach map of the Gething Formation
11 12. Schematic cross-section, Monkman Pass and Peace River Canyon areas
12 13. Schematic cross-section between Bullmoose Mountain-Sukunka River area and the British Columbia-Alberta border
13 14. Type section of the Gething Formation
13 15. The Gaylard, Bullmoose and Chamberlain members at Bullmoose Mountain
15 16. The Cadomin, Gething and Moosebar formations at Dumbgoat Mountain
15 17. Conglomerate of the Gething Formation at Dumbgoat Mountain
16 18. Sandstone of the Gaylard Member at borehole BP 81-13
17 19. Gaylard strata at type locality in Peace River Canyon
17 20. Gaylard Member at type locality in Peace River Canyon
19 21. Unit of the Gaylard Member, Peace River Canyon
19 22. Core from the upper Gaylard Member at borehole BP 53
20 23. Gaylard Member, coarsening-upward cycle
21 24. Close-up of part of the core shown in Figure 23
22 25. Fining-upward sequence, Gaylard Member, Carbon Creek
23 26. Cadomin Formation and Gaylard Member, west side of Peace River Canyon

23 27. Cadomin Formation and Gaylard Member, east side of Peace River Canyon
24 28. Cadomin and Gething formations near Mount Gorman
26 29. Epsilon crossbedding in sandstone of the Gaylard Member at Bennett Dam
26 30. Deformed crossbedding in sandstone of the Gaylard Member at Bennett Dam
27 31. Ripple crossbedding in sandstone of the Gaylard Member at Bennett Dam
27 32. Ripple crosslamination in Gaylard Member, Carbon Creek Basin
27 33. Stacked ripple lamination in Gaylard Member, Carbon Creek Basin
28 34. Syneresis cracks in core of Gaylard Member from Carbon Creek Basin
28 35. Syneresis cracks in sandstone of the Gaylard Member, Peace River Canyon
28 36. Bioturbated siltstone and sandstone of the Gaylard Member
29 37. Large herbivorous dinosaur track in the Gaylard Member
29 38. Rootlets in floodplain sandstone of the Gaylard Member
29 39. Close-up of rootlets in floodplain sandstone of the Gaylard Member
29 40. Silicified log in the Gaylard Member
30 41. Bullmoose and Chamberlain members and Moosebar Formation at Bullmoose Mountain
30 42. Cliff-forming sandstones of Chamberlain Member at Bullmoose Mountain
31 43. The shoreface transition facies of the upper Bullmoose Member
31 44. Rhythmic alternations of sandstone to mudstone in the Bullmoose Member
32 45. The Bullmoose and Chamberlain members in the Monkman-Stony Lake area
33 46. Close-up of core from the Bullmoose Member
36 47. *Chondrites* sp. in core of the Bullmoose Member
37 48. The Moosebar Formation and the Chamberlain Member of the Gething Formation at Bullmoose Mountain
38 49. Conglomerate, sandstone, siltstone, and mudstone of the Chamberlain Member in core from Petro-Canada DDH 81-04
40 50. Sandstone in the Chamberlain Member, in core from Petro-Canada DDH 81-04
40 51. Interbedded conglomerate and sandstone of the Chamberlain Member
42 52. Rhythmic alternations of sandstone, siltstone and mudstone, in core from the Chamberlain Member
42 53. Wavy bedded sandstone in mudstone of the Chamberlain Member
43 54. Close-up view of part of the core shown in Figure 53
43 55. Mottled mudstone to siltstone facies in the Chamberlain Member
44 56. Close-up view of mottled mudstone-siltstone shown in Figure 55
45 57. Moosebar Formation, showing basal transgressive conglomerate lag
46 58. The Moosebar Formation and the Chamberlain Member, in core from Petro-Canada DDH 81-04
47 59. Crossbedding in shoreface sandstone of the Chamberlain Member at Bullmoose Mountain
48 60. Crossbedding and lamination in shoreface sandstone of the Chamberlain Member, Monkman-Stony Lake area
48 61. Intersecting laminae in shoreface sandstone of the basal Chamberlain Member
49 62. *Paleophycus* sp. burrows in the Chamberlain Member
50 63. *Macaronichnus* sp. burrow traces in sandstone of the Chamberlain Member
55 64. The Cadomin, Gething and Moosebar formations at Mount Torrens
55 65. The Cadomin and Gladstone formations near Grande Cache, Alberta

STRATIGRAPHY, SEDIMENTOLOGY, COAL GEOLOGY AND DEPOSITIONAL ENVIRONMENTS OF THE LOWER CRETACEOUS GETHING FORMATION, NORTHEASTERN BRITISH COLUMBIA AND WEST-CENTRAL ALBERTA

Abstract

The Aptian to Early Albian Gething Formation comprises a nonmarine to marine sequence of interstratified conglomerate, sandstone, siltstone, mudstone and coal, and ranges from 18 m to approximately 1100 m thick. In the Burnt-Sukunka rivers area and part of the Monkman-Stony Lake area, the formation is subdivided into three lithostratigraphic units which, in ascending order, are the Gaylard (new), Bullmoose (new) and Chamberlain (now formally defined and revised) members. South and southeast of this area, the Bullmoose Member, a marine tongue, thins and can no longer be recognized, so that subdivision of the Gething succession is no longer possible. South of Kakwa River, the Gething grades laterally into strata of the Gladstone Formation of the Luscar Group. North of the Burnt-Sukunka rivers area, both Chamberlain and Bullmoose strata grade laterally into marine siltstone, mudstone and rare sandstone of the Moosebar Formation. Accordingly, the total Gething Formation in this region, including the type section at Peace River Canyon, is correlative with only the Gaylard Member of the Burnt-Sukunka rivers area to the south.

Coal of potential importance occurs in the Chamberlain (medium volatile bituminous) and Gaylard (high volatile A bituminous to semi-anthracite) members and undifferentiated Gething Formation (high to medium volatile bituminous) south of the Monkman-Stony Lake area.

The analysis of sedimentary facies, facies relationships and petrographic data, megafossil, microfossil and microfloral assemblages, and sedimentary and biogenic structures suggests that most strata of the Gething Formation were deposited in a deltaic coastal plain or paralic depositional environment.

Résumé

La formation de Gething, de l'Aptien à l'Albien inférieur, se compose d'une séquence dont la nature varie de non marine à marine de conglomérat, de grès, de microgrès, de pélite et de charbon interstratifiés. Sa profondeur varie de 18 à environ 1100 mètres. Dans la région des rivières Burnt et Sukunka, de même que dans une partie de la région de Monkman et du lac Stony, elle se subdivise en trois unités lithostratigraphiques soit, dans l'ordre ascendant, les membres de Gaylard (nouveau), Bullmoose (nouveau) et Chamberlain (officiellement défini et étudié). Au sud et au sud-est de cette région, le membre de Bullmoose, une langue d'origine marine, s'amincit et ne peut plus être distingué; il devient alors impossible de subdiviser la succession de Gething. Au sud de la rivière Kakwa, la formation de Gething passe latéralement dans des strates de la formation de Gladstone du groupe de Luscar. Au nord de la région des rivières Burnt et Sukunka, les membres de Chamberlain et de Bullmoose se transforment latéralement pour devenir le microgrès marin, la pélite et le grès moins fréquemment rencontré de la formation de Moosebar. Par conséquent, l'ensemble de la formation de Gething dans cette région, y compris le stratotype du canyon de Peace River, ne peut être corrélé qu'avec le membre de Gaylard de la région des rivières Burnt et Sukunka, vers le sud.

Un important gisement de charbon pourrait se manifester dans les membres de Chamberlain (charbon bitumineux à moyenne teneur en matières volatiles) et de Gaylard (charbon bitumineux à haute teneur en matières volatiles), ainsi que dans l'ensemble de la formation de Gething (charbon bitumineux de moyenne à haute teneurs en matières volatiles), au sud de la région de Monkman et du lac Stony.

L'analyse des faciès sédimentaires, des liens entre chacun, des données sur la pétrographie, des macrofossiles, des microfossiles, des associations microvégétales ainsi que des structures d'origine sédimentaire et biologique semble indiquer que la majorité des strates de la formation de Gething ont été mises en place dans une plaine côtière deltaïque ou dans un milieu stratigraphique paralique.

INTRODUCTION

The Lower Cretaceous Gething Formation of the Western Canada Basin forms part of a thick, northwesterly trending belt of Jurassic-Cretaceous marine and nonmarine siliciclastic rocks within the Rocky Mountain Foothills and Interior Plains of northeastern British Columbia and west-central Alberta. Since the early 1900s, Gething strata have been of economic interest because of their potential as sources of coal. Unfortunately, because of the remoteness of the region in which the coals were first discovered and with a lack of accessible markets, little interest was directed toward their economic exploitation until the late 1940s. Even then, Gething coal was only used for local consumption in the towns of Dawson Creek and Fort St. John. Because of the increased world demand for metallurgical coal, coupled with the escalation of world oil prices in the 1970s, interest in coal and coal exploration was renewed in northeastern British Columbia, with attention first directed toward the Gething Formation in the areas of Carbon Creek Basin and Sukunka River. Later, the Gething, in addition to the overlying Gates Formation, became an exploration target in the regions of Quintette Mountain and the Monkman-Stony Lake area (Fig. 1). As a result of the exploration in northeastern British Columbia, a considerable amount of core, borehole information and geophysical data became available.

The writer's interest in the lithostratigraphy and depositional environments of the coal-bearing Gething Formation began in 1974, with a detailed study of selected Gething cores from the Carbon Creek Basin of the Peace River Coalfield (Gibson, 1985a). In 1979, investigation of the Gething Formation was renewed and extended to include other coal-bearing areas of northeastern British Columbia and west-central Alberta. In addition, the project was expanded to include field exposures.

The following report, based on 20 field sections, 34 coal exploration borehole cores, and 19 geophysical and lithological well logs from petroleum exploration boreholes (Fig. 1), provides new information and data on: 1) lithofacies, lithofacies relationships, age and correlation, and significant new lithostratigraphic marker units; 2) the distribution of coal seams; 3) the occurrence and distribution of marine intervals; and 4) the depositional setting of the Gething and immediately adjacent formations. It is anticipated that this information will be useful in providing a regional geological model that will be of assistance in assessing the potential coal quality and resources of the area, and as well, be applicable to other regions with a similar geological setting.

Previous work

Since the first geological reconnaissance investigations of Selwyn (1877), Dawson (1881) and McConnell (1893, 1896), which included brief notations and/or descriptions of strata now included as part of the Gething Formation, a considerable amount of geological information has been obtained on the coal-bearing strata of the Gething Formation. Reports by Galloway (1913, 1915), Galloway (1924), McLearn (1918, 1923), McLearn and Irish (1944), Spivak (1944), Mathews (1947), McLearn and Kindle (1950), Bell (1956), Pugh (1960), Stott (1960, 1961, 1962, 1963, 1968, 1969, 1973), Rudkin (1964), and Hughes (1964, 1967) have described and documented in varying detail the geology, fauna, flora and age, coal geology, paleogeography, depositional history, and depositional environments of the Gething Formation. Most of these earlier investigations concerned the area including and adjacent to the Peace and Pine rivers, which today forms part of the Peace River Coalfield of British Columbia. The numerous publications and geological maps provided by F.H. McLearn and, in particular, D.F. Stott of the Geological Survey of Canada still serve today as authoritative reference guides to our understanding of Lower Cretaceous stratigraphy and, more specifically, the stratigraphy of the Gething Formation in northeastern British Columbia. The reports by Stott in 1968 and 1973 summarize all available information on the Gething Formation in British Columbia up to the end of 1970. To avoid repetitious review of the specific contributions to the study of the Gething Formation by most workers cited above, the interested reader is referred to the two summary reports by Stott (op. cit.).

Since 1970, accelerated coal exploration programs have generated new information concerning the lithostratigraphy, coal petrology, paleogeography and sedimentary environments of the Gething Formation. Stott (1974, 1975, 1983, 1984) continued his stratigraphic investigations of the Cretaceous in the Rocky Mountain Foothills, providing additional information and data on coal geology, depositional setting and paleogeography of the Lower Cretaceous rock succession, including the Gething Formation. Wallis and Jordan (1974), described and discussed the Gething stratigraphy and structure in the Sukunka River area. They divided the Gething into two units which they informally named the Upper and Lower Gething Formation. This work was later followed by local studies that involved Gething strata, by Gilchrist (1979, 1980), Gilchrist, Flynn and Hauser (1978), Stott and Gibson (1980), and Karst (1979a, b; 1981). In 1981, Duff and Gilchrist, in a report on the correlation of Lower Cretaceous coal measures in the Peace River Coalfield, described the occurrence of a significant marine lithofacies in the upper Gething Formation of the Sukunka River area, a facies first noted by geologists of the Coalition Mining and British Petroleum exploration companies. In addition, Duff and Gilchrist described an informal new member in the Gething Formation overlying the marine tongue, and called it the Chamberlain member. As part of the coal measures correlation investigation, Duff (1978, 1979) outlined the occurrence of tonsteins and bentonites in the Gething Formation, and later, with Spears (Spears and Duff, 1981, 1984), described the mineralogy, geochemistry and origin of tonsteins and bentonites in the Peace River Coalfield. Karst (1979b, 1981) and Karst and White (1980) began an investigation of the vitrinite reflectance of Gething Formation coals, in an attempt to correlate seams in the upper Gething Formation. These investigations were followed by those of Kalkreuth (1982a, b) who described and discussed the composition and rank of Gething coals in the Peace River Coalfield. Legun (1983; 1984a, b; 1985a, b), as part of an ongoing assessment of coal measures in northeastern British Columbia, discussed the lithostratigraphy of the Gething Formation from specific coal prospect areas in the Peace River Coalfield and, in addition, discussed the occurrence and distribution of the recently discovered Gething marine tongue. Kilby (1984a, b; 1985), in a continuing investigation of the occurrence, distribution and chemistry of tonsteins and bentonites in Lower Cretaceous rocks of northeastern British Columbia, including those of the Gething Formation, demonstrated their use as a new "tool" for local and regional lithological correlation, and, most importantly, for coal seam correlation within the Gething Formation. McLean (1982), as part of a regional study of the Lower Cretaceous in the Alberta Foothills, described the lithostratigraphy of the Gething Formation and its lateral equivalent the Gladstone Formation in the Grande Cache-Smoky River area.

Other recent investigations concerning or involving strata of the Gething, include: coal rank and thermal maturation studies by Kalkreuth and McMechan (1984); Lower Cretaceous paleogeographic investigations by Jackson (1984), Smith, Zorn and Sneider (1984), and Stott (1983, 1984); and lithostratigraphic, sedimentological and nomenclatural investigations by Jerzykiewicz and Langenberg (1983), Kilby and Oppelt (1985), Oppelt (1986), Gibson (1985a), and Langenberg and McMechan (1985).

Acknowledgments

The writer wishes to thank BP Exploration Canada Limited, Crowsnest Resources Limited, Quintette Coal Limited (formerly Denison Coal Limited), Esso Canada Resources Limited, Gulf Canada Resources Limited, Pan Ocean Limited, Petro-Canada Exploration Inc., Utah Mines Limited, and their respective staffs, for kindly providing access to their respective coal properties, granting permission to examine available core, and providing valuable assistance and co-operation that facilitated acquisition of field and subsurface information during the course of the project.

Palynological, microfossil and macrofossil identifications (including suggested age and environmental assignments) were provided by A.R. Sweet, D.J. McIntyre, N. Ioannides[1], J.H. Wall and J.A. Jeletzky. W.D. Kalkreuth provided all coal reflectance and rank data and served as a valuable field assistant in 1980 and 1981. R.A. Davidson and B.L. Gorham analysed selected coal samples for sulphur content. A.G. Heinrich and J.N. Wong provided X-ray diffraction analyses of many samples. W.O. McEwan provided many excellent thin sections. P. Dobell plotted several of the columnal sections in Figures 3 to 10. To all these Geological Survey of Canada staff members and colleagues I am truly grateful.

Some of the ideas and interpretations concerning the stratigraphy and depositional environments were developed and improved through discussions with colleagues D.F. Stott, D.A. Leckie, A.R. Sweet, and J.H. Wall of the Geological Survey of Canada, and with R.D. Gilchrist, R. Karst, W.E. Kilby, and A. Legun of the Geological Survey Branch, British Columbia Ministry of Energy, Mines and Petroleum Resources (Fort St. John).

Special thanks are offered to the staff, especially Ken Clark, at the British Columbia Ministry of Energy, Mines and Petroleum Resources core storage facility at Charlie Lake, for their assistance in moving many hundreds of core boxes during the investigation.

Able assistance in the field was provided by D. O'Dowd in 1979, and by F. Frosini in 1982.

---

[1] Formerly of the Geological Survey of Canada.

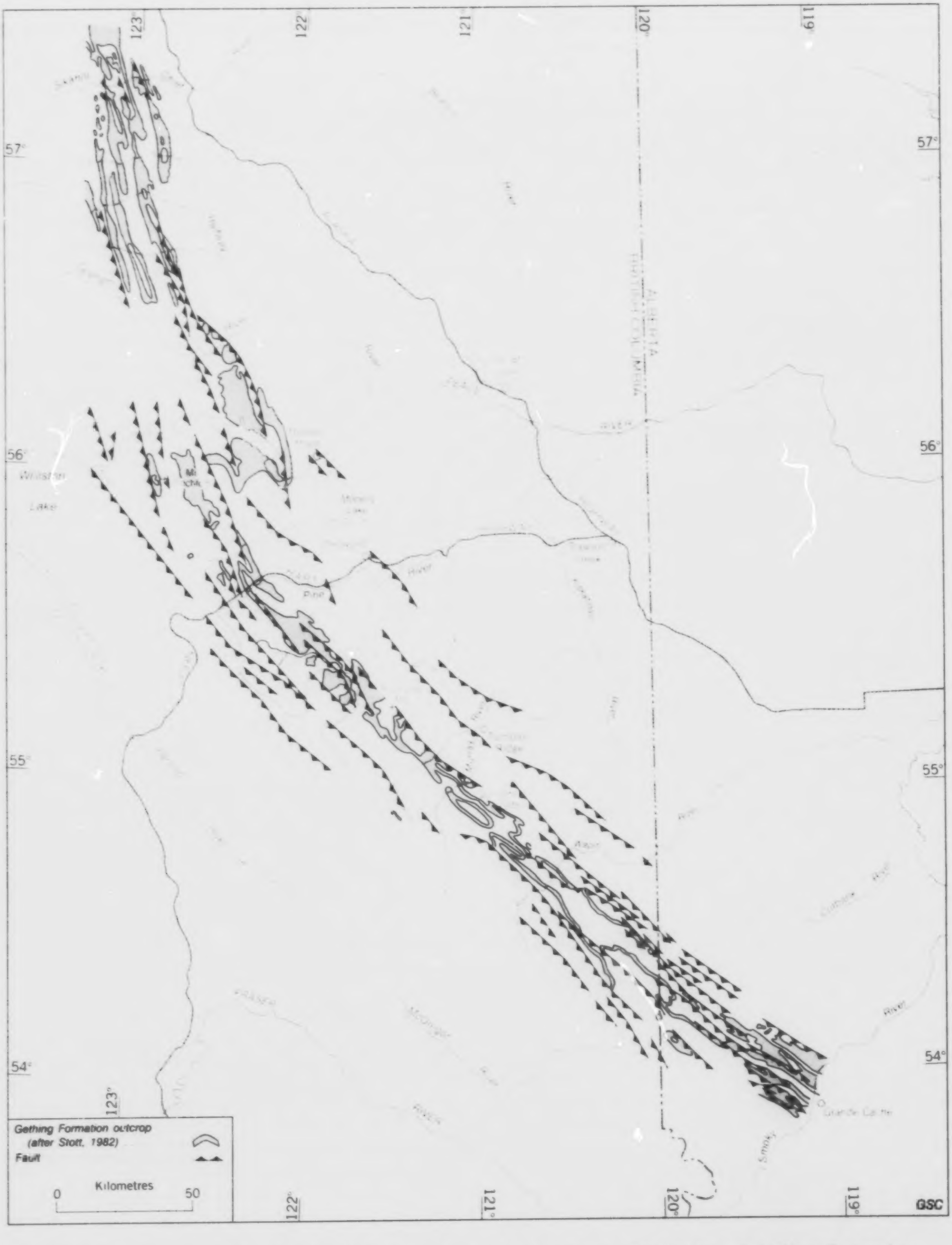
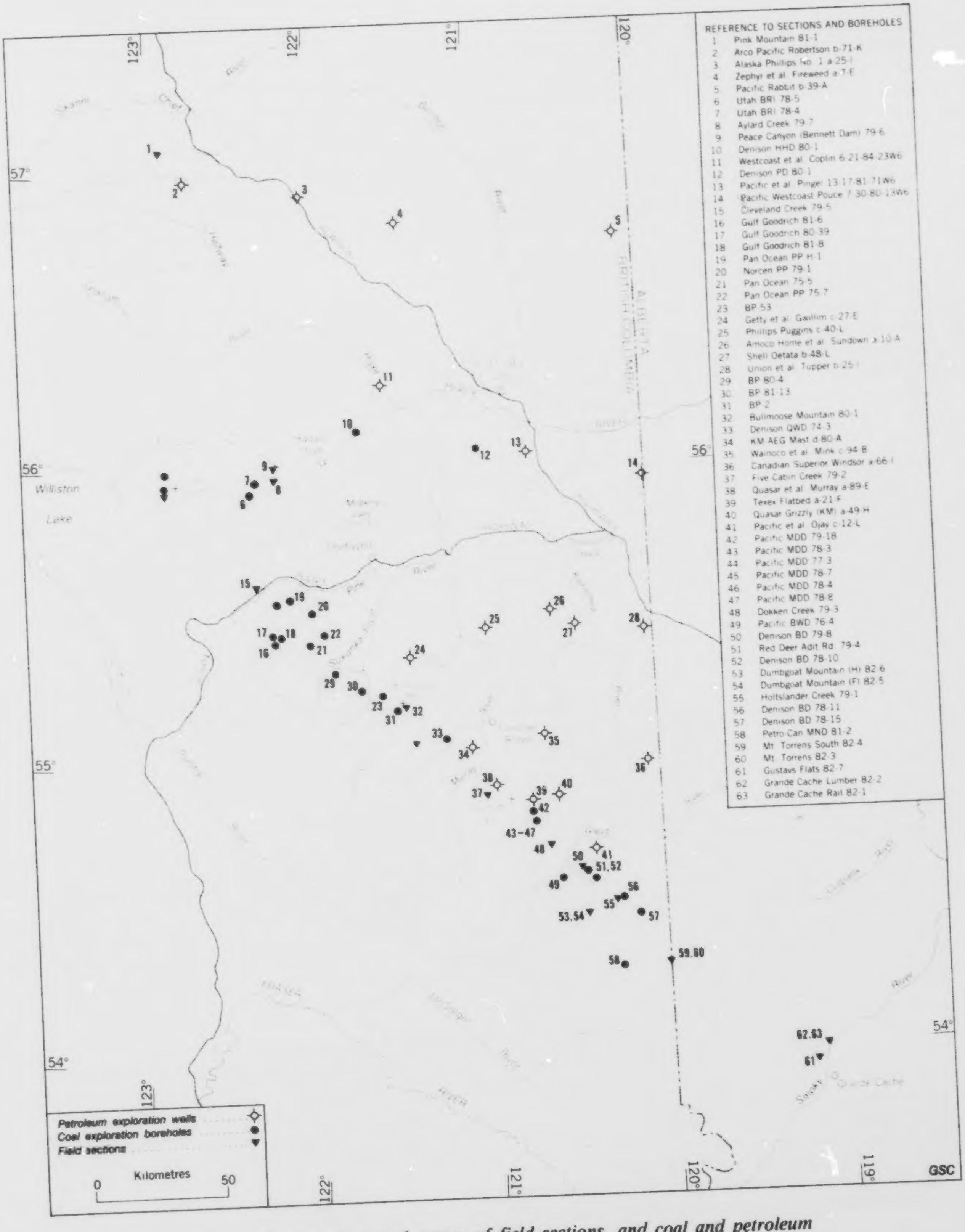

123°
122°
121°
120°
119°
57°
56°
55°
54°
Williston
Lake
ALBERTA
BRITISH COLUMBIA
PEACE
RIVER
River
Grande Cache
Smoky
FRASER
RIVER
Gething Formation outcrop
(after Stott, 1982)
Fault
Kilometres
0
50
GSC

Figure 1a. Index map showing location of study area and outcrop distribution of Gething Formation.



REFERENCE TO SECTIONS AND BOREHOLES
1 Pink Mountain 81-1
2 Arco Pacific Robertson b-71-K
3 Alaska Phillips No. 1 a-25-I
4 Zephyr et al. Fireweed a-7-E
5 Pacific Rabbit b-39-A
6 Utah BRI 78-5
7 Utah BRI 78-4
8 Aylard Creek 79-7
9 Peace Canyon (Bennett Dam) 79-6
10 Denison HHD 80-1
11 Westcoast et al. Coplin 6-21-84-23W6
12 Denison PD 80-1
13 Pacific et al. Pingel 13-17-81-71W6
14 Pacific Westcoast Pouce 7-30-80-13W6
15 Cleveland Creek 79-5
16 Gulf Goodrich 81-6
17 Gulf Goodrich 80-39
18 Gulf Goodrich 81-8
19 Pan Ocean PP H-1
20 Norcen PP 79-1
21 Pan Ocean 75-5
22 Pan Ocean PP 75-7
23 BP 53
24 Getty et al. Gwillim c-27-E
25 Phillips Puggins c-40-L
26 Amoco Home et al. Sundown a-10-A
27 Shell Oetata b-48-L
28 Union et al. Tupper b-25-I
29 BP 80-4
30 BP 81-13
31 BP 2
32 Bullmoose Mountain 80-1
33 Denison QWD 74-3
34 KM AEG Mast d-80-A
35 Wainoco et al. Mink c-94-B
36 Canadian Superior Windsor a-66-I
37 Five Cabin Creek 79-2
38 Quasar et al. Murray a-89-E
39 Texex Flatbed a-21-F
40 Quasar Grizzly (KM) a-49-H
41 Pacific et al. Ojay c-12-L
42 Pacific MDD 79-18
43 Pacific MDD 78-3
44 Pacific MDD 77-3
45 Pacific MDD 78-7
46 Pacific MDD 78-4
47 Pacific MDD 78-8
48 Dokken Creek 79-3
49 Pacific BWD 76-4
50 Denison BD 79-8
51 Red Deer Adit Rd. 79-4
52 Denison BD 78-10
53 Dumbgoat Mountain (H) 82-6
54 Dumbgoat Mountain (F) 82-5
55 Holtslander Creek 79-1
56 Denison BD 78-11
57 Denison BD 78-15
58 Petro-Can MND 81-2
59 Mt. Torrens South 82-4
60 Mt. Torrens 82-3
61 Gustavs Flats 82-7
62 Grande Cache Lumber 82-2
63 Grande Cache Rail 82-1
123°
122°
121°
120°
119°
57°
56°
55°
54°
ALBERTA
BRITISH COLUMBIA
Williston Lake
Grande Cache
Petroleum exploration wells
Coal exploration boreholes
Field sections
Kilometres
0
50
GSC

Figure 1b. Locations and names of field sections, and coal and petroleum exploration boreholes used in this report.

STRATIGRAPHY OF THE GETHING FORMATION

Introduction

Strata of the coal-bearing Lower Cretaceous Gething Formation described in this report extend from the Grande Cache–Smoky River area of Alberta in the south, to the Pink Mountain and Halfway River area of British Columbia in the north (Fig. 1). South of Kakwa River, the nomenclature changes and equivalent beds are assigned to the Gladstone Formation of the Luscar and Blairmore groups (Fig. 2). Toward the east and southeast the Gething grades into, or correlates with, the McMurray Formation and Dina Member of the Lower Manville Group in the Alberta Plains. Northward, the Gething "shales out", grading laterally and vertically into marine shales of the lower Garbutt and Buckinghorse formations of the Fort St. John Group (Stott, 1973). Throughout most of the area the Gething is overlain by marine strata of the Moosebar Formation of the Fort St. John Group, although in some areas of the subsurface in the eastern Foothills and western Plains it is overlain by strata of the Bluesky Formation of the Fort St. John Group (Fig. 2). North of Williston Lake and Peace River, the Gething is overlain by marine strata of the Moosebar-equivalent Buckinghorse Formation of the Fort St. John Group. In most areas the Gething Formation is gradationally underlain by the Cadomin Formation, although in the Plains, east of Sikanni Chief and Halfway rivers, it is underlain by the Cretaceous Buick Creek Formation, Jurassic Fernie Formation, or Triassic Schooler Creek Group (see Figure 10). In the far north, the Gething is underlain by Triassic strata of the Schooler Creek Group (Stott, 1973).

In a recent report, the writer described the subsurface lithostratigraphy of the Gething Formation in the Carbon Creek Basin (Gibson, 1985a, Fig. 1). This investigation also provided information, data and a discussion of the coal geology, coal seam correlation and depositional environments of these strata in the area. The present report is a continuation of the earlier project, but is now expanded to include the Gething Formation in other regions of northeastern British Columbia, and the Gladstone Formation in the Grande Cache–Smoky River area of west-central Alberta. In addition to the coal exploration data from the Carbon Creek area, much new coal exploration borehole data, and new stratigraphic information from several field

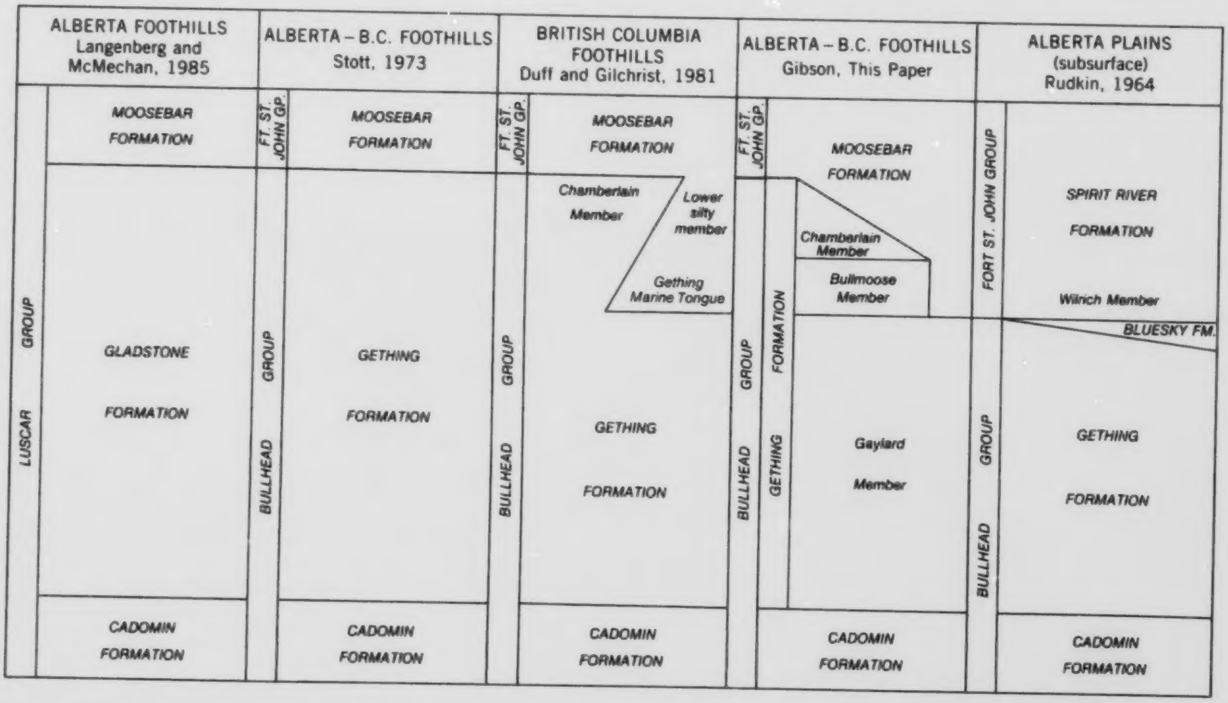

ALBERTA FOOTHILLS
Langenberg and McMechan, 1985
ALBERTA – B.C. FOOTHILLS
Stott, 1973
BRITISH COLUMBIA FOOTHILLS
Duff and Gilchrist, 1981
ALBERTA – B.C. FOOTHILLS
Gibson, This Paper
ALBERTA PLAINS
(subsurface)
Rudkin, 1964
LUSCAR GROUP
MOOSEBAR FORMATION
GLADSTONE FORMATION
CADOMIN FORMATION
FT. ST. JOHN GP.
BULLHEAD GROUP
MOOSEBAR FORMATION
GETHING FORMATION
CADOMIN FORMATION
FT. ST. JOHN GP.
BULLHEAD GROUP
MOOSEBAR FORMATION
Chamberlain Member
Lower silty member
Gething Marine Tongue
GETHING FORMATION
CADOMIN FORMATION
FT. ST. JOHN GP.
BULLHEAD GROUP
GETHING FORMATION
MOOSEBAR FORMATION
Chamberlain Member
Bullmoose Member
Gaylard Member
CADOMIN FORMATION
FORT ST. JOHN GROUP
BULLHEAD GROUP
SPIRIT RIVER FORMATION
Wilrich Member
BLUESKY FM.
GETHING FORMATION
CADOMIN FORMATION

Figure 2. Nomenclature chart and subdivisions of the Gething Formation used by the writer in this report, and nomenclature used by other workers in the report area and adjacent area to the east.

sections and petroleum exploration boreholes are included in the study. Some reference to the Carbon Creek area is necessary in order to modify some of the preliminary earlier interpretations concerning formation definition, contact relationships and depositional environments.

Nomenclature and formation definition

Strata of the Gething Formation were first defined by McLearn (1918) as a distinctive coal-bearing member of the upper Bullhead Mountain Formation. In 1923, he formally named the unit the Gething Member of the Bullhead Mountain Formation, assigning a lower contact "where conglomerate and grits disappear and coarse sandstones become rare [Cadomin Formation of this report], and medium to fine sandstone, shale, clay, ironstone and coal beds become common." He observed that the top of the Gething Member was characterized by an 18 inch (46 cm) thick bed of sandstone containing scattered pebbles, a facies which today is included as part of the marine Moosebar Formation of the Fort St. John Group. McLearn (1923) designated a type section for the Gething along the north bank of Peace River west of Grant Flat and up Aylard Creek. The Gething Member was later elevated to formation status within the newly named Bullhead Group by Beach and Spivak (1944). The underlying conglomerates, grits and coarse grained sandstones adjacent to the Gething were defined as part of the Dunlevy Formation by Beach and Spivak (op. cit.), and redefined later by Stott (1962, 1963) as the Cadomin Formation. In 1964, Hughes designated the strata the Dresser Formation.

Stott (1968, 1969) re-examined the Gething Formation type locality of McLearn and, because of inaccessibility, described a better and more continuously exposed supplemental reference section for the Gething, upstream from the McLearn section, along the west side of Peace River Canyon (now a cliff-forming exposure on the shore of Dinosaur Lake). Eighteen hundred feet (550 m) of strata (see Figure 9) are exposed at this new reference locality.

The recognition of a thick succession of marine strata within the Gething Formation by Duff and Gilchrist (1981), resulted in a new stratigraphic subdivision of the Gething Formation in the Sukunka River–Quintette Mountain area of northeastern British Columbia. They proposed that the formation be subdivided into three units, a lower coal-bearing unit, a middle marine unit, and an upper coal-bearing unit. The marine unit was interpreted by Duff and Gilchrist (op. cit.) as a facies of the overlying Moosebar Formation, although they still included the unit as part of the Gething Formation. It was called the "Gething Marine Tongue" (Fig. 2). Strata overlying the marine succession were informally named the Chamberlain member. Recent investigations by Karst and White (1980), White (1983) and Williams (1984) of the lithostratigraphy and correlation of the Bluesky Formation of the eastern Foothills and western Interior Plains, have led to the suggestion or implication that all strata above the base of the "Marine Tongue", including the Chamberlain member of the Gething Formation, may be interpreted as equivalent to the subsurface Bluesky Formation as recognized by the petroleum industry. However, to adopt or accept this suggestion, would necessitate redefining the upper contact of the Gething Formation in the Sukunka River, Bullmoose Mountain, and Quintette Mountain areas.

Kilby (1984b, 1985) and Legun (1984a, 1985a), working on the recognition and definition of the Bluesky and Gething formations in part of the Peace River Coalfield, noted the occurrence of a distinctive lithological marker facies, consisting of marine glauconitic sandstone, mudstone, pebbly mudstone and chert-pebble conglomerate. The marker facies, first recorded by McLearn (1923), occupies the interval between the relatively thick marine mudstone, siltstone and shale of the Moosebar Formation and the underlying coal-bearing strata of the Gething Formation. This distinctive lithostratigraphic unit has informally been referred to as an occurrence of the Bluesky Formation. Kilby (op. cit.), using information from Duff and Gilchrist (1981), and chemical and mineralogical analytical data from tonstein-bentonite marker horizons in the Gething and Moosebar formations in the Peace River Coalfield, demonstrated that the glauconitic marine marker horizon ("Bluesky Formation"), between the Moosebar and Gething formations in the vicinity of Pine and Peace rivers north of Sukunka River, was not coeval with a similar glauconitic marker facies between the Gething and Moosebar formations south of Sukunka River in the vicinity of Bullmoose Mountain. The marine marker facies north of Sukunka River was demonstrated to be older than that found between the Gething and Moosebar formations south of Sukunka River. Investigations by Legun (op. cit.) and the writer south of Sukunka River and in the vicinity of Bullmoose Mountain have revealed another distinctive glauconitic sandstone marker horizon near or at the base of the middle Gething, Bullmoose Member marine tongue. This glauconitic lithofacies may correlate with the glauconitic sandstone and pebble conglomerate horizon recognized by Kilby north of Sukunka River. The discovery by Kilby of the two glauconitic marker horizons at different stratigraphic levels, and the recognition of the glauconitic sandstone unit near or at the base of the Bullmoose Member, indicate that the economically important coal-bearing Chamberlain Member is younger and occurs stratigraphically above uppermost Gething strata in the region north of Burnt and Sukunka rivers. This conclusion is also supported by the work of Legun (1984a, 1985a).

The identification of the glauconitic marker facies, the discovery of the marine tongue in the middle of the Gething Formation in the Burnt-Sukunka rivers and Quintette Mountain areas of the Foothills, and the extension and use of the name Bluesky Formation for these marine strata, have created a nomenclatural and stratigraphic problem. What lithofacies or stratigraphic criteria define the Gething, Bluesky and Moosebar formations in the report area?

These strata were first described by Badgley (1952), but it was the Alberta Study Group (1954) that defined and named the Bluesky Formation as a marine succession of predominantly glauconitic sandstone with chert pebbles and shale, up to 46 m thick, overlying strata of the coal-bearing Gething Formation in the subsurface of the Alberta Interior Plains. The formation, as defined by the Study Group, does not contain either the coal or nonmarine, carbonaceous or coaly shale lithofacies which, in contrast, characterize much of the Gething Formation described in this report. Pugh (1960), in a subsequent study of the subsurface Gething and Bluesky formations in the easternmost Foothills and Plains of northeastern British Columbia, extended recognition and the name Bluesky Formation to a succession of clastic rocks occurring between Moosebar Formation shales and coal-bearing rocks of the Gething Formation. These rocks were similar in composition and occupied a similar stratigraphic position to those at the type locality of the Bluesky Formation in Alberta. The reference section, designated by Pugh (op. cit.) in British Columbia for the subsurface Bluesky Formation, consists mainly of glauconitic sandstone with minor glauconitic shale. In the Foothills area to the west, Pugh (op. cit.) and recently Legun (1984a), also noted the occurrence of a relatively thick conglomerate and sandstone facies, up to 40 m thick, between the Moosebar and Gething formations. They interpreted this lithofacies as equivalent to the type Bluesky Formation in the subsurface of the Plains. It is suggested herein, however, that these unusual and locally thick sandstones and conglomerates in the Foothills and Plains areas of northeastern British Columbia may not be of the same age, or equivalent to those of the type Bluesky Formation in Alberta, but may occur at different stratigraphic levels.

In order to avoid unnecessary confusion in defining the Gething Formation and assigning formational contacts between the Gething Formation and overlying Bluesky and/or Moosebar formations of the Fort St. John Group, and at the same time to conform with and retain the original definition of the Gething Formation as recognized in the Foothills by McLearn (1923), Stott (1968, 1973) and most other workers, including the writer, strata of the Gething Formation in this report will be defined on the basis of their content of coal seams, carbonaceous and coaly mudstones and siltstones, and the overall marginal marine deltaic character of the strata. In contrast, it is suggested that strata of the Moosebar and Bluesky formations should be defined to include only marine non-coal-bearing strata. However, it must be noted that where fine to medium grained, thick bedded sandstones, devoid of coal seams and finer grained carbonaceous strata, occur immediately above the coarsening-upward marine succession of siltstones and mudstones of the Bullmoose Member in the Foothills belt northeast of Sukunka River and Bullmoose Mountain (Fig. 7), these sandstones are included and interpreted in this report as part of the upper Gething, Chamberlain Member, and not as a unit or lithofacies of the Bluesky or Moosebar formations. It is herein suggested that in all areas of the Gething Formation outcrop belt (Fig. 1) described in this report, where thin or locally thick deposits of pebbly mudstone, glauconitic sandstone and pebbly conglomerate occur between the Moosebar Formation and the Gething Formation, isolated and far removed from the thicker main facies of the subsurface Bluesky Formation of the easternmost Foothills and Plains region, the name Bluesky be avoided, and the marine marker lithofacies between the Gething and Moosebar formations be included as part of the recessive weathering, dark grey siltstones, mudstones and shales of the lower part of the Moosebar Formation.

The contact between the Gething and the underlying Cadomin Formation ranges from gradational to abrupt, and generally does not present a stratigraphic problem in defining the base of the Gething Formation.

In the Burnt-Sukunka rivers and Monkman-Stony Lake areas, the Gething Formation can be subdivided into three distinct lithostratigraphic units which, in ascending order, are named: the Gaylard, Bullmoose, and Chamberlain members (Fig. 2). This subdivision was first proposed by Duff and Gilchrist (1981) for the Gething in the Foothills of the Sukunka River-Quintette Mountain area. However, the unit boundaries adopted by the writer differ from those proposed by Duff and Gilchrist (op. cit.) and will be discussed below during the discussion of the three lithostratigraphic units. In the region south and southeast of a line connecting Monkman Lake, Stony Lake and Redwillow River (Fig. 1), the Bullmoose Member can no longer be readily identified. The Gething Formation in this area is therefore undifferentiated.

Lithology, thickness and age relationships

The Gething Formation in northeastern British Columbia comprises an interstratified sequence of nonmarine, marine and marginal marine sandstone, siltstone, mudstone and coal with, locally, pebble and intraformational conglomerate which, in most regions, constitute part or all of the three members of the formation (Figs. 3-10). Each of the members is composed of up to eight distinct lithofacies or lithofacies associations. These are as follows:

1. Conglomerate and conglomeratic sandstone
2. Fine to coarse grained sandstone
3. Very fine grained sandstone to siltstone
4. Rhythmically bedded very fine grained sandstone, siltstone and mudstone
5. Mudstone
6. Claystone
7. Miscellaneous rock types such as carbonate and ironstone
8. Coal (This important rock type of the Gething will be described and discussed separately.)

The Gething ranges in thickness from a maximum of 1100± m near Mount Rochfort south of Williston Lake, to a minimum of 18 m in the vicinity of the British Columbia-Alberta border northeast of Fort St. John (Fig. 11). The maximum value recorded near Mount Rochfort is approximate, because the contact with the overlying Moosebar Formation is not exposed in the area (Legun, 1985b). Isopachs (Fig. 11) based on field, coal and petroleum exploration borehole data, show a general thinning trend for the Gething southwest to northeast. The conspicuous thickening west of the Tumbler Ridge, Chetwynd, Hudson Hope and Halfway River areas, may in part result from shortening and stacking produced by thrust faulting (Fig. 1). However, the lateral thrust displacements within the Gething of the region are small (McMechan, pers. comm., 1986) and, accordingly, may not have had a significant effect on thickness trends in the area. The regional thickness trend therefore appears to be a result of sediment accumulation. In the same area, however, another trend is illustrated by the westerly thickening lobe that occurs in the vicinity of Peace River between Dawson Creek and Fort St. John, and extends to the area of Mount Rochfort and Williston Lake. This trend may in part reflect the presence and/or tectonic influence of the Peace River Arch, or perhaps outlines the configuration of a major sediment lobe of the Gething delta (Stott, 1968). The irregular but increasing thickness trend for the area southeast of Murray River and Tumbler Ridge, again may be the result of the tectonic influence of the Peace River Arch and perhaps, to a lesser degree, a result of the intertonguing relationship between the Gething, Cadomin and Bluesky formations, where contact assignment between the formations is in some cases difficult. Intertonguing between the Cadomin and Gething formations east and north of Wapiti Lake and Belcourt River, results in a prominent lithofacies change between the two formations which again is reflected by anomalous thickening and thinning trends in the Gething Formation in the area. Toward the southwest, the Gething Formation is relatively thin while, in contrast, the Cadomin Formation is relatively thick (Stott, 1968). Toward the northeast the Cadomin Formation thins, resulting in a proportionate increase in the thickness of the Gething Formation.

The precise age of the Gething Formation has in the past generally proven difficult to establish. Stott (1973) indicated that the Gething is Hauterivian to earliest Albian, an assignment based mainly on stratigraphic position within the Lower Cretaceous rock succession and to a lesser degree on fossil collections and suggestions by other workers. For example, macrofloral identifications by Bell (1956, *in* Stott, 1973) suggested an Aptian and/or Early Albian age for the Gething. McGregor (*in* Stott, 1973), using a microfloral assemblage, considered the Gething to be Valanginian or possibly Aptian in age. Chamney, in the same report, identified foraminifers from the Gething and assigned an age of late Neocomian (Barremian-Aptian) to Early Albian. Recently, the writer reported the occurrence of marine bivalves from the Gething Formation in the Carbon Creek Basin, which were assigned an Aptian age (Gibson, 1985a).

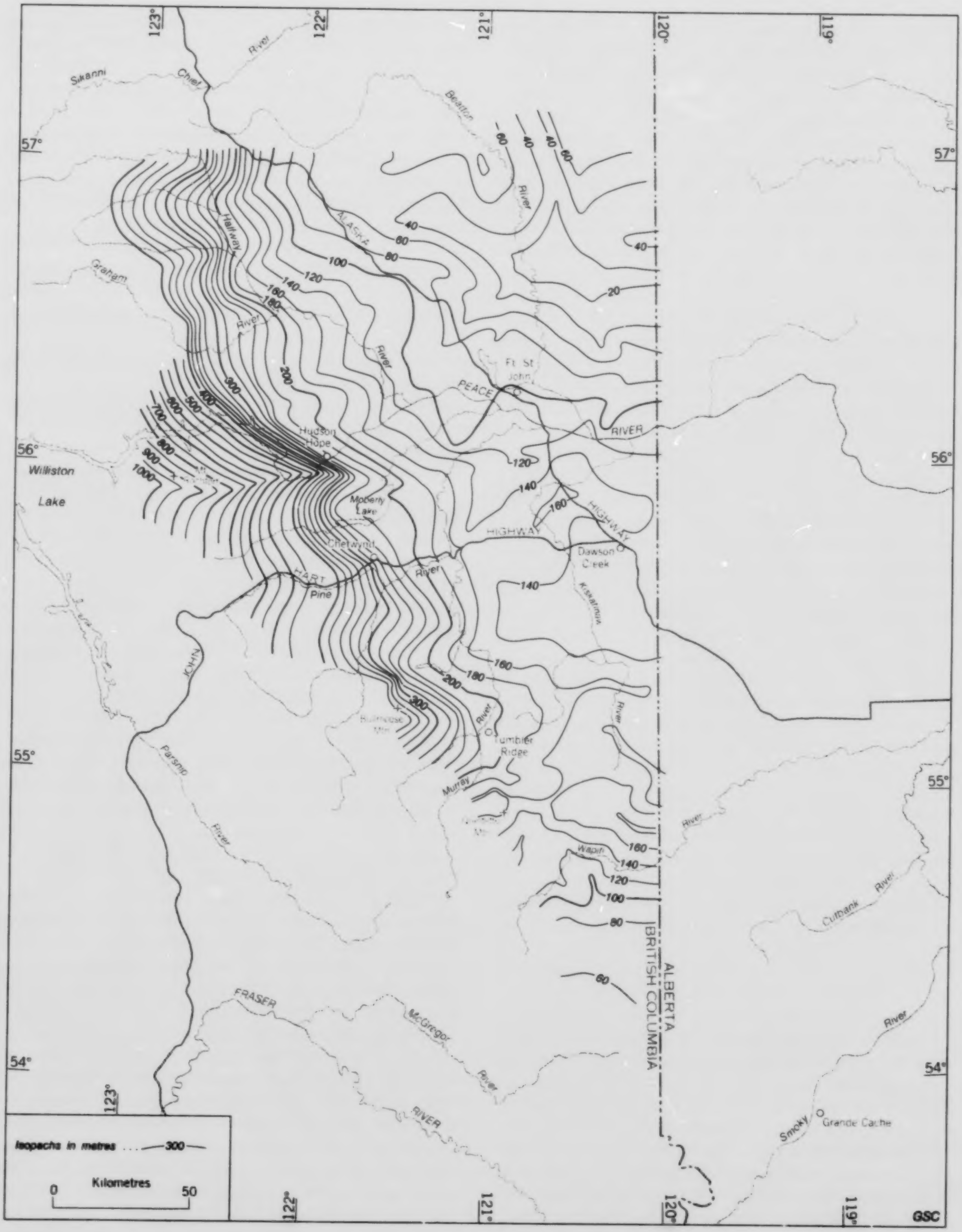

123°
122°
121°
120°
119°
Sikanni
Chief
River
Beatton
River
57°
57°
60
40
40
60
Halfway
ALASKA
Graham
River
40
60
80
100
120
140
160
180
40
20
River
200
300
400
500
600
700
800
900
1000
Ft St John
PEACE
RIVER
Hudson Hope
56°
56°
Williston
Lake
120
140
160
HIGHWAY
HIGHWAY
Moberly Lake
Chetwynd
Dawson Creek
HART
Pine
River
140
Kiskatinaw
JOHN
160
180
200
300
Bullmoose Mtn
River
Tumbler Ridge
55°
55°
Parsnip
River
Murray
River
Wapiti
160
140
120
100
80
60
River
Cutbank
River
FRASER
McGregor
River
ALBERTA
BRITISH COLUMBIA
54°
54°
RIVER
Smoky
Grande Cache
River
Isopachs in metres ... 300
Kilometres
0
50
GSC

Figure 11. Isopach map of the Gething Formation.

During the course of the present investigation, several microfossil assemblages, from samples collected by the writer, were identified by J.H. Wall as definite Early Albian. These microfossils were obtained from a stratigraphic level above that of the Aptian bivalves of the Carbon Creek Basin area. Therefore, based on the recent age assignments, the Gething Formation can now be dated as having an age which ranges from Aptian to Early Albian. It must be noted, however, that because of the interfingering relationship between the Gething and Cadomin formations in some southern areas, and the fact that the Cadomin has been dated as possibly Hauterivian (Stott, 1968), lowermost Gething strata also may be that age in some areas.

A more comprehensive discussion of the age and age relationships of the Gething Formation will be included in the discussion of the component members.

GAYLARD MEMBER

Definition, distribution and thickness

The Gaylard Member of the Gething Formation comprises the stratigraphic interval occurring between the massive, thick bedded conglomerate and sandstone of the Cadomin Formation below, and the generally finer grained, argillaceous, marine siltstones, sandstones and mudstones of the Bullmoose Member above (Figs. 5-10, 12, 13). North and northeast of the Burnt–Sukunka rivers and Bullmoose Mountain areas (Fig. 1), where Bullmoose strata grade laterally into the Moosebar Formation (Figs. 7, 12), the total Gething interval consists of strata equivalent to the Gaylard Member alone. In this northerly region, the Gething Formation, or Gaylard Member, is overlain by recessive, marine siltstones, shales and rare sandstones

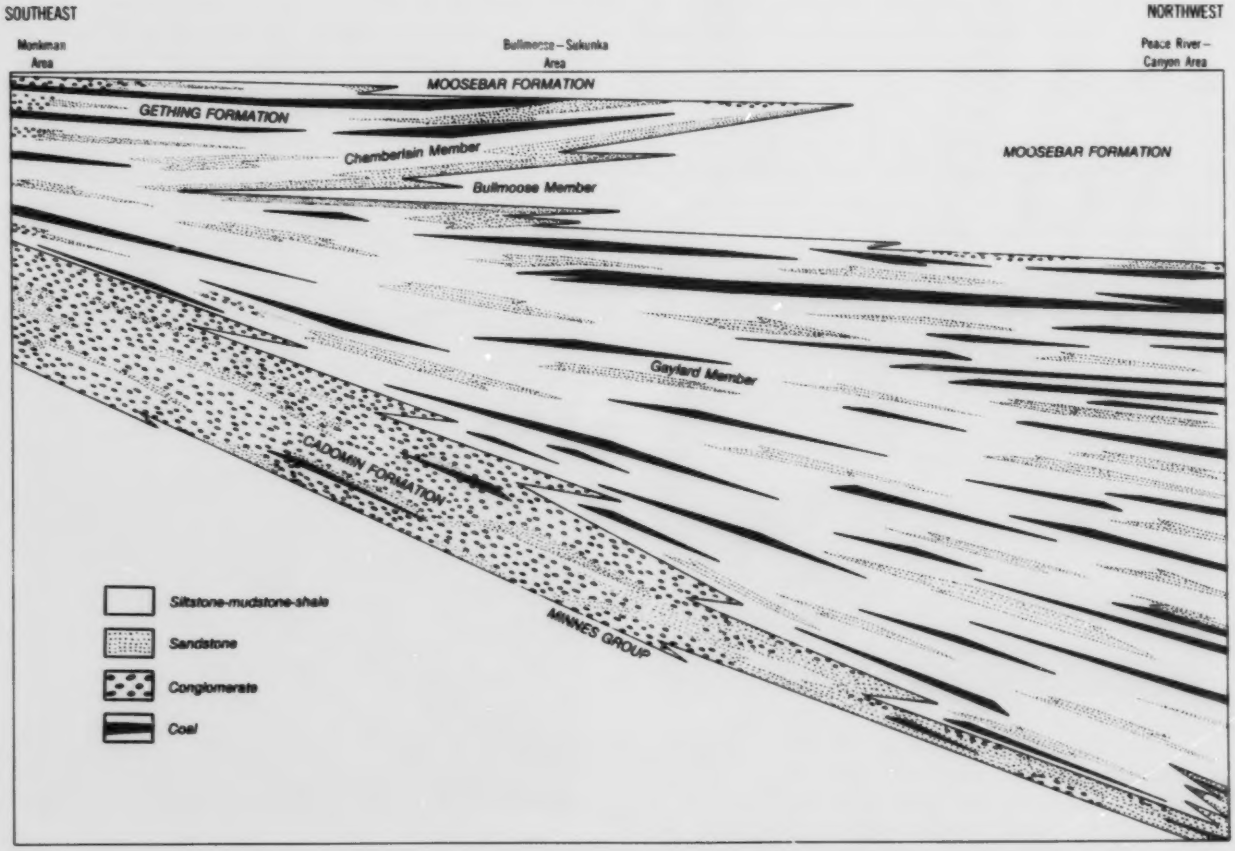

SOUTHEAST
NORTHWEST
Monkman Area
Bullmoose–Sukunka Area
Peace River–Canyon Area
MOOSEBAR FORMATION
GETHING FORMATION
Chamberlain Member
Bullmoose Member
MOOSEBAR FORMATION
Gaylard Member
CADOMIN FORMATION
MINNES GROUP
Siltstone-mudstone-shale
Sandstone
Conglomerate
Coal

Figure 12. Schematic cross-section illustrating lithofacies and stratigraphic relationships among the Cadomin, Gething and Moosebar formations of the Rocky Mountain Foothills, between the Monkman Pass and Peace River Canyon areas.

of the Moosebar Formation, and locally by marine sandstones and conglomerates of the Bluesky Formation (Fig. 9). South of the Monkman-Stony Lake and Redwillow River areas (Fig. 1), Gaylard strata cannot be separated from the total Gething because of the absence of, or great difficulty in recognizing, the Bullmoose Member. Accordingly, Gaylard strata are included as part of an undifferentiated Gething Formation. It should be noted, however, that because of the occurrence of rare lithostratigraphic marker horizons (bentontic claystones), one can still recognize strata and stratigraphic intervals that are approximately equivalent to the Gaylard Member in the north.

The first attempt to subdivide the Gething Formation into discrete stratigraphic units was made by Wallis and Jordan (1974), in an area near Sukunka River and Bullmoose Mountain. They recognized two units which they called the "upper Gething sequence" and the "lower Gething sequence". The lower Gething was defined as the stratigraphic interval lying or occurring below a thick economically important coal horizon called the Chamberlain Seam. The lower Gething of Wallis and Jordan (op. cit.) included strata herein defined as part of the Chamberlain and Bullmoose members and all of the Gaylard Member. As noted previously, Duff and Gilchrist (1981) subdivided the Gething into three units (Fig. 2), the lowest of which was called the "lower Gething unit". This unit was overlain by a coarsening-upward succession of marine mudstones and siltstones and very fine grained sandstones which they named the "Gething marine tongue". However, contact relationships between the subdivisions and in particular those of the "lower Gething unit" were not clearly defined. They do, however, appear to approximately coincide with those adopted in this report. No type section or reference locality was designated by Duff and Gilchrist (op. cit.) for the three units.

The Gaylard and other members of the Gething Formation are generally poorly exposed (talus and/or grass and tree covered), with many areas characterized mainly by resistant weathering "ribs" of sandstone and/or conglomerate separated by covered intervals (see Figs. 15, 16, 28). Accordingly, complete or nearly complete field exposures of the Gaylard Member were difficult to find. However, because of extensive coal exploration many complete Gething Formation cores

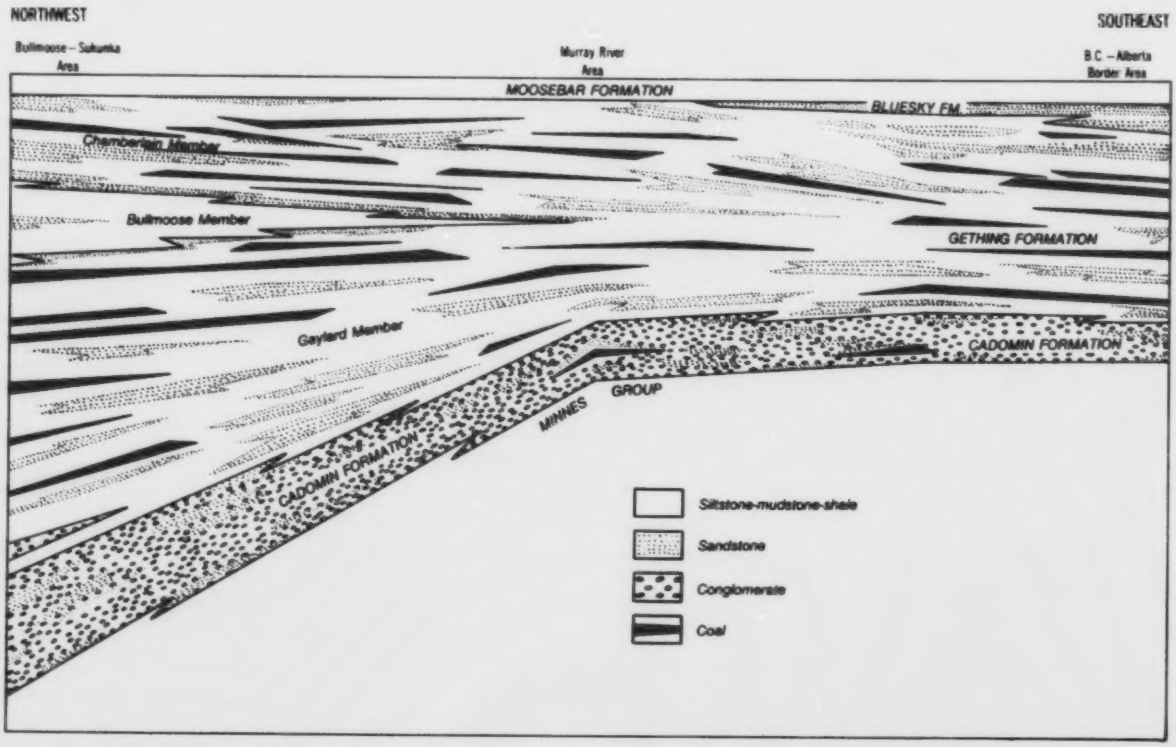

NORTHWEST
SOUTHEAST
Bullmoose – Sukunka Area
Murray River Area
B.C. – Alberta Border Area
MOOSEBAR FORMATION
BLUESKY FM.
Chamberlain Member
Bullmoose Member
GETHING FORMATION
Gaylard Member
CADOMIN FORMATION
CADOMIN FORMATION
MINNES GROUP
Siltstone-mudstone-shale
Sandstone
Conglomerate
Coal

Figure 13. Schematic cross-section illustrating lithofacies and stratigraphic relationships among the Cadomin, Gething and Moosebar formations of the Rocky Mountain Foothills and Plains between Bullmoose Mountain–Sukunka River area and the British Columbia–Alberta border.

were available. The type and supplemental reference sections of the Gething Formation near W.A.C. Bennett Dam (Stott, 1968, p. 23; 1969; 1973, p. 206) (Fig. 9) consist of strata equivalent to only the Gaylard Member as defined in this report (Fig. 12). However, because of better exposure and easier access to the new reference locality at the base of the dam, it is designated the type section of the Gaylard Member (Fig. 14, NTS 94 B/1, UTM 548300E, 6207300N). The name Gaylard is derived from Gaylard Creek, a tributary of Gething Creek. In the Burnt-Sukunka rivers area, where Gaylard strata are overlain by the Bullmoose Member, the exposure at Bullmoose Mountain serves as an additional field reference section illustrating all typical lithofacies (Sec. 80-1; Figs. 6, 12, 15). The Bullmoose locality is accessible by helicopter from the town of Chetwynd, or by four-wheel drive vehicle via a newly constructed highway south of Chetwynd, then proceeding westward along the Tech Corporation coal haulage road to Bullmoose Mine, then proceeding northwestward via a British Petroleum gas well service road adjacent to Saddle Creek. A 1.5 km hike up a small intermittent stream on the south side of Bullmoose Mountain is required in order to reach the section (Fig. 1; UTM 596300E, 6116500N; topographic map of Bullmoose Creek, NTS 93 P/3, 1:50 000 scale). A lithological description of the Gething Formation at Bullmoose Mountain, including the Gaylard Member of this report, may be found in Stott (1968) and in Appendix 3 of this report.

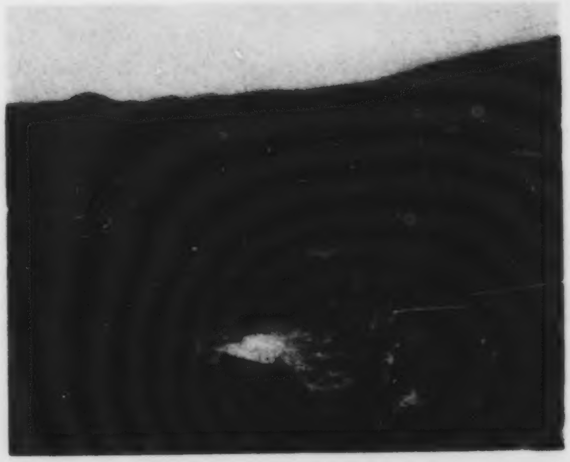


Figure 14. Type section of the Gething Formation at Peace River Canyon (Dinosaur Lake), illustrating lithofacies typical of Gaylard Member. Gaylard Member (Gy); Cadomin Formation (Cd). ISPG photo. 2649-8.

In addition to the field exposures, strata of the Gaylard Member may also be examined in several cores. Complete and typical facies of the Gaylard Member from different regions in the report area may be examined in core from the following boreholes: Denison Wolverine 74-03 (Fig. 6; UTM 611800E, 6103800N; topographic map of Bullmoose Creek, NTS 93 P/3, 1:50 000 scale), Denison HHD 80-01 (Fig. 9; UTM 579000E, 6220300N; topographic map of Hudson Hope, NTS 94 A/4, 1:50 000 scale), Denison PD 80-01 (Fig. 9; UTM 622500E, 6215000N; topographic map of Moberly River, NTS 94 A/3, 1:50 000 scale), and Pacific MDD 78-07 (Fig. 5; UTM 644187E, 6071487N; topographic map of Kinuseo Creek, NTS 93 I/15, 1:50 000 scale). An additional example of Gaylard strata, although incomplete, may be examined in core from borehole BP 53 (Fig. 7; UTM 588170E, 6120861N; topographic map of Sukunka River, NTS 93 P/4, 1:50 000 scale). All Gething Formation and Gaylard Member cores may be examined at the core storage and examination facilities of the Ministry of Energy, Mines and Petroleum Resources, Charlie Lake, British Columbia.

Strata of, or equivalent to, the Gaylard Member occur throughout the study area. However, where recognized as a distinct and lithologically separate facies of the Gething Formation, the Gaylard interval is limited to areas bounded by the Burnt and Sukunka rivers, Bullmoose Mountain, Gwillim Lake and

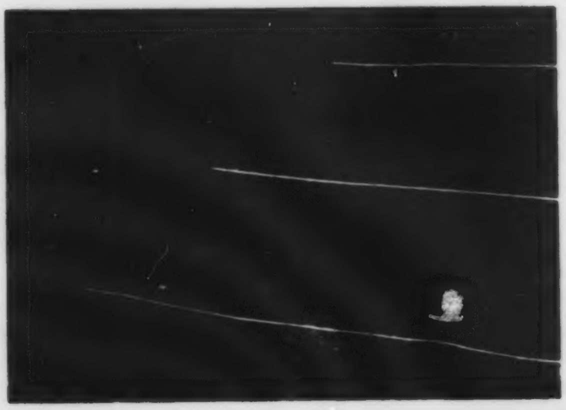


Figure 15. Contact and lithological relationships of the Gaylard, Bullmoose and Chamberlain members at Bullmoose Mountain. Note marker sandstone capping strata of Gaylard Member and resistant cliff-forming character of Chamberlain Member. Gaylard Member (Gy); Bullmoose Member (Bm); Chamberlain Member (Ch); Moosebar Formation (Mb). ISPG photo. 2649-4.

Kiskatinaw River south of the Shell Detata b-48-L well (NTS 93 P/8), in the north; the Monkman–Stony Lake and Redwillow River area to the south; and the British Columbia–Alberta border to the east (Figs. 5-8). As noted and discussed previously, Kilby (1985) demonstrated that all strata of the Gething Formation north of the Burnt and Sukunka rivers, particularly in the vicinity of Pine and Peace rivers and Williston Lake, are equivalent to only the Gaylard interval in the Burnt and Sukunka rivers area and other areas to the south (Fig. 12). Gaylard strata can be traced northward into the vicinity of Tetsa River, where they grade laterally into marine rocks of the Garbutt Formation (Stott, 1968). Although present in part of the area south of a line connecting Monkman Lake, Stony Lake and Redwillow River, Gaylard strata are difficult to distinguish from strata of the Chamberlain Member, because of the absence of, or difficulty in recognizing, strata of the Bullmoose Member marine tongue (see Figure 13 for the stratigraphic relationships).

The Gaylard Member ranges in measured thickness from a maximum of 1100± m in the vicinity of Mount Rochfort (Legun, 1985b) to a minimum of 58 m near Stony Lake (Pacific MDD 78-08 well, Fig. 5a). At the type section at Peace River Canyon the Gaylard Member is 556 m thick. At Bullmoose Mountain, where all members of the Gething Formation are exposed, the Gaylard is 149 m thick. Figure 6 reveals a marked west to east thinning trend for the Gaylard Member and a comparison of Figures 5 and 6 indicates a regional thinning trend toward the south and southeast into the Monkman–Stony Lake area. In the Belcourt River, Belcourt Lake and other areas to the south, Gaylard strata cannot be separated from rocks of the overlying Chamberlain Member and, therefore, the Gething Formation is undifferentiated.

Lithology

The Gaylard Member comprises an interstratified sequence of conglomerate, sandstone, siltstone, mudstone-shale, and thin to thick seams of medium volatile bituminous to semianthracite coal (Figs. 5-10). Seven lithofacies or lithofacies assemblages are recognized: conglomerate and conglomeratic sandstone; very fine to coarse grained sandstone; siltstone; mudstone; claystone; rhythmically bedded sandstone, siltstone and mudstone-shale; and miscellaneous lithofacies. Coal, although a distinct and typical lithofacies of the Gaylard, will be described under a separate heading.

Conglomerate and conglomeratic sandstone

Conglomerate and conglomeratic sandstone represent two of the most conspicuous rock types of the Gaylard Member, forming thin to thick units commonly associated with the coarser grained sandstones (Figs. 5, 7). In outcrop they form massive cliffs, similar in appearance to those of the underlying Cadomin Formation (Fig. 16).

The conglomerate consists of well rounded, ovoid to elongate, moderately to poorly sorted pebbles, granules and cobbles, composed of light and dark grey to greenish grey chert, rare spicular chert, light grey to white quartzite, reddish brown and green quartzose sandstone, dark grey siliceous mudstone-shale, laminated dark grey siltstone; and, less commonly, grey to buff calcareous quartz sandstone, black to dark grey mudstone, dark grey limestone to dolostone with scattered crinoid columnals, white quartzite with black veining, coalspars; and rare limestone pebbles and cobbles, some of which contain corals and foraminifers. The last mentioned pebbles and cobbles occur in the Dumbgoat Mountain–Belcourt Lake area to the south (Figs. 4, 16). In this region the conglomerate facies of both the Gething and Cadomin formations form an interfingering relationship, and clast dimensions reach their maximum. For example, at Dumbgoat Mountain, cobbles up to 17 cm in longest apparent dimension may be observed, although most clasts range from 2 to 5 cm in diameter (Fig. 17). The pebble conglomerates are both clast and matrix supported; however, where pebble conglomerate forms thick beds or lenses it is mainly clast supported, with a matrix of fine to coarse grained sandstone, and a cement composed of silica and rare calcite. The conglomerate forms units ranging from approximately 1 to 18 m thick.

The closely related conglomeratic sandstone consists of "floating" or matrix supported, well rounded pebbles, similar in composition to those of the main conglomerate facies. Fine to coarse grained sandstone forms in excess of 50 per cent of the strata (Fig. 18). The conglomeratic sandstone occurs as thin or thick beds, or commonly as lenses within conglomerate, and both within and at the base of the thicker sandstone units.

Associated with the pebble conglomerate and conglomeratic sandstone facies assemblage at some localities are thin to thick lenses of mudstone-chip or edgewise conglomerate, consisting of angular to subangular clasts of dark grey siltstone to mudstone. Some clasts are 18 cm long by 4 cm wide, in a matrix

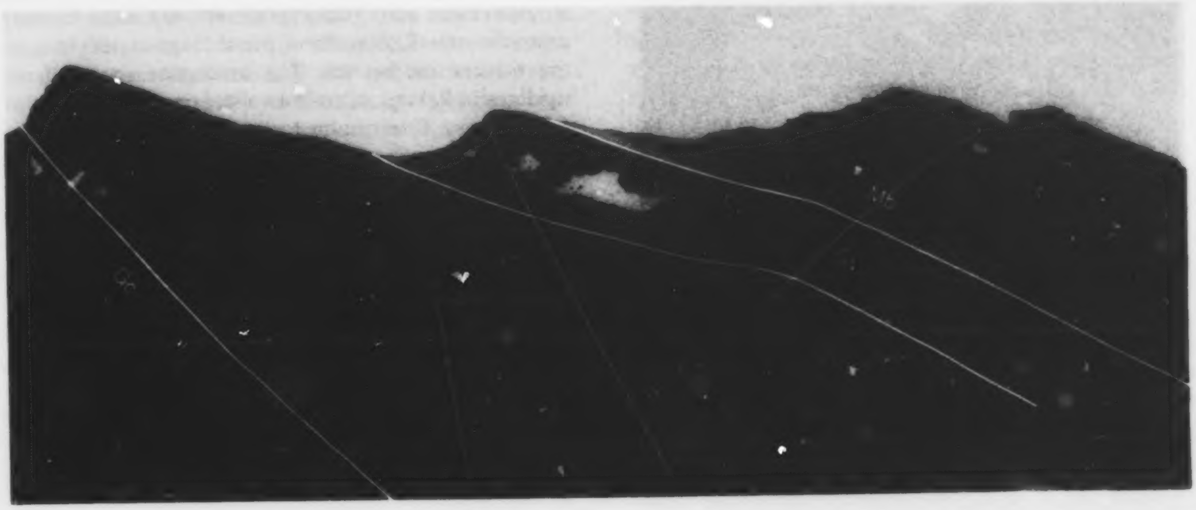


Figure 16. Contact and lithological relationships of the Cadomin, Gething and Moosebar formations at Dumbgoat Mountain (Sec. 82-5). Note thick, massive character of Cadomin Formation and relatively thin development of Gething Formation. Moosebar Formation (Mb); Gething Formation (Gt); Cadomin Formation (Cd); Gorman Creek Formation (Gc). ISPG photo. 2065-13.

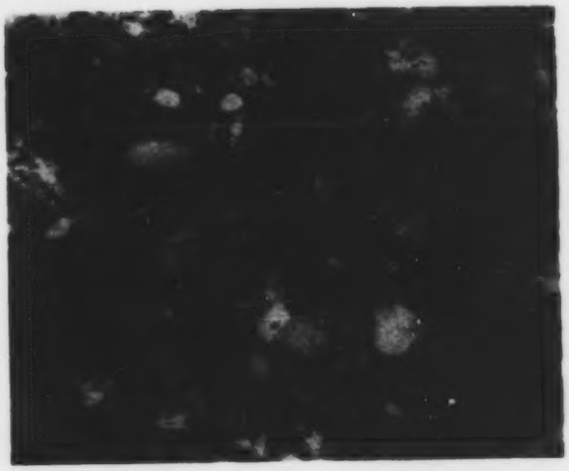


Figure 17. Chert and quartzite pebble conglomerate of the Gething Formation at Dumbgoat Mountain (Sec. 82-5), illustrating moderately sorted, well rounded, clast supported pebbles and cobbles. Conglomerate and sedimentary character similar to that of the underlying Cadomin Formation. ISPG photo. 2470-7.

of medium to coarse grained quartzose sandstone (see Gibson, 1985a, p. 15). The clasts are oriented parallel or subparallel to the bedding. Pebble or clast imbrication was not apparent.

Sandstone

Like most of the conglomerate and conglomeratic sandstone facies described above, sandstone forms a conspicuous component of the Gaylard Member. In outcrop, the coarser grained sandstones may form prominent ledges along the sides of mountain ridges and major river valleys, pinching and swelling along strike, or, in some areas, grading laterally into interbedded mudstone and siltstone (Figs. 19, 20). When combined with the conglomerate and conglomeratic facies, the coarser grained clastics (includes sandstones coarser than very fine grained) constitute approximately 12 to 43 per cent of the total Gaylard strata. At Bullmoose Mountain, for example, the conglomerate and sandstones coarser than very fine grained constitute 22 per cent of the total strata (Fig. 6). At the type section of the Gething Formation and Gaylard Member (Figs. 9, 14) coarser grained sandstone forms 28 per cent of the total Gething strata.

Sandstones of the Gaylard Member are moderately to well sorted, generally well indurated, ranging in size from predominantly very fine to coarse grained.

Figure 18. Coarse grained, quartz-chert sandstone of the Gaylard Member, illustrating well rounded pebbles of quartz sandstone and chert and abundant vitreous coalspars. Coal exploration borehole BP 81-13. ISPG photo. 2743-3.

"Floating" pebbles of chert, quartz sandstone, sideritic ironstone and other rock types randomly occur in some units; in others, they form pebble lags at the base of the thicker sandstones. The sandstone ranges from medium to light grey, to brownish grey, to dark grey in some of the finer grained more carbonaceous facies, and in outcrop weathers medium grey to brownish grey to buff, depending upon the nature and degree of exposure. Detrital components consist mainly of quartz and chert with the latter more abundant in the coarser grained sandstones. Less common are lithic grains composed of silicified mudstone, siltstone and limestone. In addition, collophane, orthoclase and plagioclase feldspar grains were noted in several thin sections. Cement consists of quartz and less commonly clay, dolomite and calcite. In outcrop, the thicker bedded, coarser grained sandstones frequently display a distinct "salt and pepper" texture, a feature attributable to the presence of light grey quartz and dark grey chert and yellow-brown, limonitic, sandstone-siltstone grains.

A typical thick sandstone can be described as follows: an erosional base with relatively coarse grains, with or without scattered, well rounded pebbles and/or angular siltstone or mudstone clasts; the coarser sandstone grades upward into finer grained sandstone commonly displaying medium- to small-scale festoon crossbedding, followed in turn by even finer grained sandstone containing ripple, climbing ripple, or ripple drift lamination. In addition, many of these finer grained intervals are capped by contorted or convolute laminae. At Pink Mountain (Fig. 10), some of the Gaylard sandstones are characterized by dark grey stylolitic laminae. Dark grey to black phytoclasts, or carbonaceous comminuted material occur as laminae along parting planes or, alternatively, occur disseminated throughout the sandstone. The greater the concentration of phytoclasts, the darker the colour of the sandstone unit—a feature typical of the finer grained sandstones interbedded with the carbonaceous siltstones and mudstones.

Siltstone

Quantitatively, siltstone appears to form the dominant lithotype of the Gaylard Member, occurring as thin to medium beds in units up to 7 m thick; thin to thick laminae; thin beds interlaminated or interbedded with fine to very fine grained sandstone; or as thin beds and laminae interbedded and interlaminated with mudstone or shale (Figs. 19, 20). Most siltstone is medium dark to dark grey and weathers medium to light grey to orange-brown. It is commonly very sandy and argillaceous, so that classification as very fine grained sandstone, sandy siltstone, silty mudstone, or very argillaceous siltstone is often difficult without a detailed laboratory, size and/or thin section, analysis. In addition, some siltstones are characterized by a high concentration of carbonate minerals, making it difficult to differentiate them from silty limestone or dolostone.

Mineralogically, the siltstone is similar to the finer grained sandstones, and is composed mainly of quartz with rare chert, feldspar and lithic grains of limestone and dolomite. Pyrite occurs as small blebs, ovoid concretions or rosettes. Clay minerals are ubiquitous and occur in variable concentrations. Those identified by X-ray analysis include illite, kaolinite, chlorite and expandable and/or mixed-layered silicates. Cement consists mainly of silica, forming a welded quartzitic texture, although in some strata it consists of calcite and minor dolomite. A variable concentration of phytoclasts characterizes many of the dark grey, fine grained siltstones, particularly those near or adjacent to coaly mudstone, shale or coal. Where siltstone occurs adjacent to coal seams, the concentration of phytoclasts increases, to form thin, vitreous lenses of coal.

An unusual, light grey to olive-grey to buff, argillaceous siltstone was noted in some Gaylard cores from the Burnt-Sukunka rivers area. It occurs interbedded with dark grey carbonaceous mudstone or shale. In outcrop the siltstone is generally dark grey, weathering a very distinctive light to medium light grey. Similar light grey weathering siltstones have been described by the writer (Gibson, 1985b) in strata of the Jurassic-Cretaceous Kootenay Group of southeastern British Columbia and southwestern Alberta. In core, these siltstones are commonly very siliceous, well indurated and characteristically contain conspicuous, dark grey, vertical rootlets and other vegetal fragments. Similar properties are found in the field samples, although in outcrop they are most conspicuous near or adjacent to thin seams of coal or coaly mudstone. In core, some of the siltstones display a prominent mottled grey to orange-brown colour. X-ray analyses of selected samples reveal a composition of mainly quartz (maximum of 88%), and clay minerals consisting of illite, expandable and/or mixed-layer silicates, kaolinite, and/or chlorite. Cement consists of silica, although clay minerals may form a conspicuous component in some samples. These siltstones display a bleached or leached appearance. Similar light grey siltstones have been observed by the writer and described recently by Leckie and Foscolos (1986) from sequences of mudstone and shale in the Lower Cretaceous Boulder Creek Formation in northeastern British Columbia. There, they are interpreted as paleosols.

Figure 19. Gaylard strata at type locality in Peace River Canyon (Dinosaur Lake), illustrating alternating resistant-recessive bedding typical of this member and the Gething Formation. Note lenticular character of channeloid sandstone at left centre of photograph. ISPG photo. 2065–20.

Figure 20. Gaylard Member at type locality in Peace River Canyon (Dinosaur Lake), near Bennett Dam overflow spillway. Note resistant-recessive weathering character of bedding and small, lenticular crevasse splay, or possible tidal channel, in centre of photo near roadway. Massive, light weathering sandstone capping section is illustrated in Figure 30. ISPG photo. 2396–15.

Mudstone

Like siltstone, mudstone forms a conspicuous and quantitatively significant component of the Gaylard Member throughout the report area. However, in outcrop, it is mainly covered by talus, grass and/or trees (Figs. 19, 20). The mudstone is medium dark to dark grey and weathers dark grey to dark brownish grey. It is very quartzose, very carbonaceous-argillaceous and contains a variable concentration of calcite, dolomite, siderite and pyrite. The concentration of calcite in some samples is such, that these samples may be classified as very quartzose, argillaceous limestone. Clay minerals, determined by X-ray analysis, include illite, kaolinite/chlorite, and expandable and/or mixed-layer silicates. The mudstone is commonly associated or interbedded with siltstone and very fine grained sandstone (Figs. 19, 20), and is most conspicuous in cores of the Gaylard Member from the Sukunka, Pine and Peace rivers areas to the north.

Two distinct mudstone lithotypes characterize much of the Gaylard strata. They are vegetal-matter-rich and vegetal-matter-free. The former and more common type is very quartzose and carbonaceous, containing a relatively high but variable concentration of whole or macerated plant matter, such as leaves, stems, grasses and other wood-like components. In addition, it commonly contains parallel to wavy, thin beds and/or laminae of siltstone, and, if adjacent to or in close proximity to coal seams, may contain thin to thick lenses of coal and/or coalspars. Accordingly, depending on the concentration of the coal, it may be classified as shaly coal. The vegetal-rich lithotype may interdigitate with many of the thin to thick seams of coal illustrated in Figures 5 to 10. The second mudstone lithotype is common to all three divisions of the Gething Formation. It is dark grey to black, containing a relatively high concentration of clay minerals, with, in addition, a noteworthy concentration of quartz. Also present are orange-brown to grey-brown, incipient, ferruginous (ironstone) nodules, nodular beds, lenticular brown ferruginous laminae, and/or ferruginous colour mottling. At some outcrop localities, ferruginous nodules are up to 10 cm in diameter. Locally, in core, pyrite laminae and rosettes are common. Plant matter is uncommon. Siltstone laminae are rare or absent. Because of their dense and compacted nature, these mudstones commonly display a distinct subconchoidal fracture. Numerous but generally indeterminate pelecypods of mainly nonmarine to possible brackish water origin characterize the facies in the region of Williston Lake and Carbon Creek Basin (Gibson, 1985a).

Claystone-tonstein

Another noteworthy lithotype, mineralogically and texturally related to the coaly to carbonaceous mudstone facies, consists of soft to moderately well indurated, pale yellowish brown to medium light grey claystone, occurring in thin beds that range from 3 to 20 cm in thickness. They are interpreted as tonsteins, representing altered volcanic ash beds. They occur both in outcrop and in many coal exploration cores, associated with thin to thick seams of coal, or occur interbedded with dark grey carbonaceous to coaly mudstones. The tonsteins consist of quartz in varying concentrations (some contain up to 58%), and clay minerals, including kaolinite, illite, chlorite and expandable and/or layered silicates. In addition, ferruginous dolomite, siderite, feldspar, anatase, and rare calcite were also recorded by X-ray analysis of selected samples. Because the tonsteins are associated with seams of coal or dark grey carbonaceous mudstones, they also contain coal particles, plant fragments or black mudstone impurities. Many of the tonsteins display a distinctive, layered or platy micaceous, granular texture.

Two main tonstein horizons, within strata herein defined as part of the Gaylard Member, were traced and chemically analysed by Kilby (1984a, 1985). The uppermost tonstein, known as the Fisher Creek Tonstein, has been correlated by Kilby (op. cit.) throughout field exposures and cored intervals of the Peace, Pine, and Burnt-Sukunka rivers areas. The interval occurs approximately 45 m below the base of the Moosebar-Gething Formation contact. A second tonstein horizon was traced throughout the same region, at a level approximately 20 m below the upper tonstein marker. The combination of these two tonstein markers, and their stratigraphic relationship to each other and to the Moosebar-Gething Formation contact, permitted Kilby to correlate two major coal seams or coal-bearing intervals, occurring near the top of the Gething Formation at Peace and Pine rivers, with coal seams or coal-bearing intervals occurring below the Bullmoose Member in the Burnt-Sukunka rivers area to the south.

Tonsteins or similar light coloured claystones were observed in outcrop and in several cores of the Gaylard Member and lower Gething Formation south of the Sukunka River-Bullmoose Mountain area, as far south as Grande Cache Alberta (Fig. 1). The tonsteins in the southern area range from 1 to 8 cm thick, but occur in the lower third to quarter of the Gething Formation, in strata herein interpreted as equivalent to the Gaylard Member of the north. In the southern areas, tonsteins have been observed at field localities at Dokken Creek (Fig. 5), Dumbgoat Mountain (Fig. 4) and Grande Cache (Fig. 3), and in cores from the Pacific Monkman (Fig. 5a) and Denison Belcourt properties (Figs. 4, 5). Because these tonstein horizons have been recognized at one or, in some sections, at two levels within the total Gething Formation of these southern areas, they may be correlative with one or both tonstein marker facies in the vicinity of and north of the Burnt and Sukunka rivers. Additional work using detailed compositional analyses is necessary to resolve this problem. It must be noted, however, that most of the thicker coals of economic interest have been removed during the coal exploration programs; accordingly, some tonsteins may have been present but subsequently removed with the coal.

Sandstone-siltstone-mudstone facies assemblage

In addition to the previously described lithological types, strata of the Gaylard Member are also characterized by a distinct lithofacies assemblage that consists of rhythmic alternations of thin bedded, very fine grained sandstone, siltstone and mudstone, comprising a conspicuous light and dark grey alternating lithological colour pattern in many cores (Figs. 21-25). In outcrop, the strata form thin bedded, resistant and recessive weathering couplets (Fig. 21). The rhythmic couplets are best developed in the thicker sections of the Carbon Creek and Peace River areas to the north, but also occur at localities near Pine, Burnt and Sukunka rivers. A similar facies assemblage characterizes much of the overlying Bullmoose Member.

Figure 21. Unit of the Gaylard Member at the type locality in Peace River Canyon (Dinosaur Lake), south side of Gething Creek; illustrating wavy, wave-rippled, and lenticular bedding. Strata consist of light weathering, very fine grained sandstone to siltstone, and dark weathering mudstone to shale. ISPG photo. 2065-21.

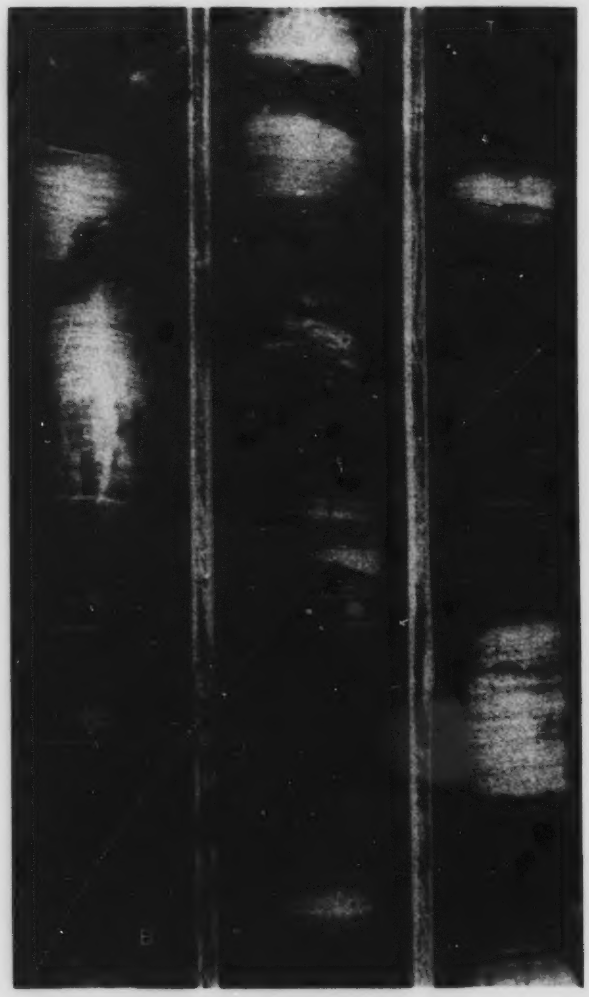


Figure 22. Rhythmic alternations of light weathering, very fine grained sandstone to siltstone and darker weathering mudstone in core from the upper Gaylard Member at borehole BP 53. Note fining-upward, sharp based sandstone tempestites o. turbidites, well developed syneresis cracks, and horizontal Planolites-like burrow traces. Top of core (T). Bottom of core (B). ISPG photo. 2470-2.

A typical rhythmic facies consists of sharp based, medium grey, fine to very fine grained sandstone at the base, with well developed ripple laminae, and distorted laminae, grading upward into darker grey, carbonaceous, sandy siltstone, which in turn is overlain by dark grey to black carbonaceous mudstone to shale (Figs. 22, 25). Most couplets range from 2 to 4 cm in thickness, although, locally, the darker grey siltstones and mudstones may be much thicker. In places, the dark grey mudstone is overlain by thin seams or lenticles of coal. The rhythmic couplets may be incomplete, consisting only of interbedded and/or interlaminated, very fine grained sandstone and siltstone with no mudstone interbeds. Alternatively, interbedded siltstone and mudstone with no conspicuous sandstone beds or sand laminae also occur. In outcrop, the rhythmic facies assemblage forms wavy to lenticular beds or occurs as isolated rippled lenses, giving the interval a wavy to nodular-like appearance (Fig. 21). Locally, the thicker sandstones of the assemblage display well developed mud flasers. Some of the thicker intervals of the facies assemblage in the Carbon Creek Basin attain thicknesses of up to 9 m and display a distinct coarsening-upward profile (Fig. 23). In this region, the dark grey to black mudstone at the base of the couplet contains little or no obvious vegetal matter, but displays a conspicuous subconchoidal fracture. The mudstone is gradationally overlain by wavy, lenticular to parallel bedded siltstone and sandstone, followed in turn by a relatively thick unit of very fine to fine grained bioturbated and burrowed sandstone.

Figure 23. Gaylard Member illustrating coarsening-upward cycle of wavy to lenticular bedded mudstone and sandstone at base, grading into very fine to fine grained sandstone of possible interdistributary bay or coastal estuary origin. Note bioturbation of dark weathering mudstone and ripple laminated sandstone. Top of core (T). Bottom of core (B). ISPG photo. 2470–10.

Miscellaneous facies

The miscellaneous facies includes limestone, dolostone and ubiquitous banded and mottled ironstone, ironstone nodules and concretions. Thin section analysis of two samples, from the Pacific 77-3, (Fig. 5) and BRI Dowling No. 4 boreholes near Peace River (Fig. 9), revealed the presence of thin beds of very quartzose sandy limestone, within fine grained channel-like sandstones. The limestone consists of subangular to subrounded grains of quartz and chert, detrital grains of limestone and probable dolomite, in a medium to coarsely crystalline, recrystallized calcite cement and matrix. Clay minerals and opaque carbonaceous matter permeate much of the cement and matrix. Silty quartzose dolostone was noted in the BRI Dowling No. 4 borehole, near Peace River (Fig. 9). There, it occurs as a thin, very argillaceous bed within one of the thin, fining-upward sandstone-siltstone-mudstone facies assemblages described above. The dolostone bed consists of finely crystalline dolomite containing angular silt-sized grains of quartz, and permeated by dark grey, comminuted, carbonaceous matter, visible plant fragments and clay minerals. The silty to sandy, quartzose limestones and dolostones may be more common, but have gone undetected because of poor exposure or, alternatively, have been misidentified as calcareous or dolomitic sandstone, siltstone or mudstone. Laboratory analysis is necessary for accurate identification.

Thin ironstone bands and mottled bedding occur in many of the finer grained siltstones, mudstones and shales. The ironstone is sideritic, commonly calcareous, dark greyish brown to orange-brown in colour, and forms wavy to lenticular bands 2 to 3 cm thick. In outcrop it occurs as thin beds, lenses, and large and small isolated ovoid concretions, some of which are up to 50 cm in diameter, and most of which weather a conspicuous ochre or orange-brown colour.

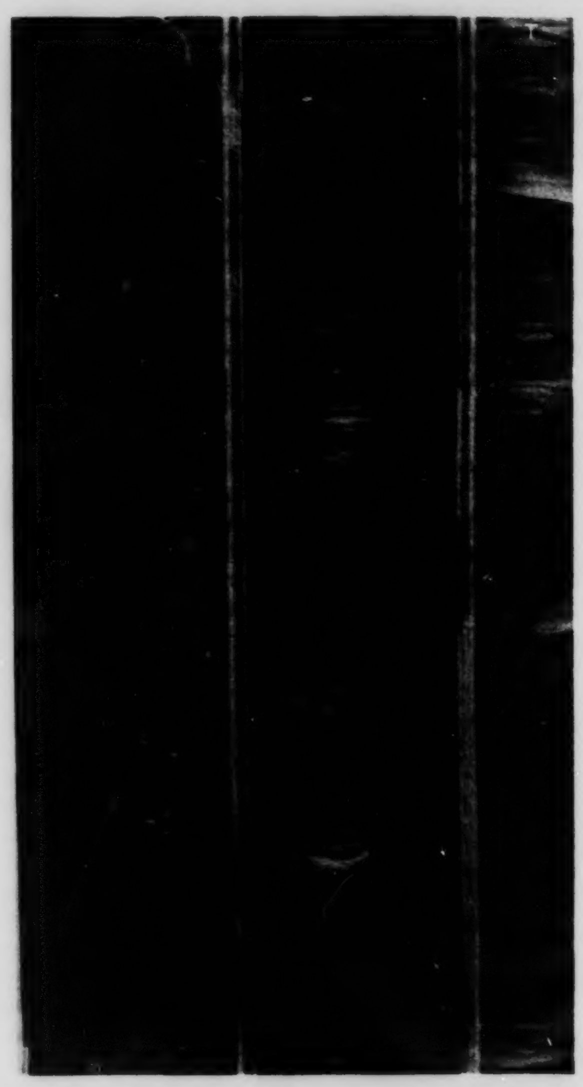


Figure 24. Close-up of part of the core shown in Figure 23, illustrating wavy to lenticular laminated mudstone-siltstone facies, possibly related to an interdistributary bay or estuary environment. Note bioturbation and increasing frequency and thickness of light weathering sandstone beds toward top. Top of core (T). Bottom of core (B). ISPG photo. 2065-9.

Facies variations

Facies variations are common because of the deltaic depositional setting interpreted for much of the Gething Formation. Accordingly, correlation of lithotypes or facies assemblages is difficult in most areas, even between closely spaced boreholes and field sections. Stott (1968, 1973) in his investigation of the Bullhead Group, described some of the noteworthy regional facies variations of the Gething Formation in the report area. Gibson (1985a), using several stratigraphic cross-sections, documented the noteworthy lithofacies variations in the lower Gething, or Gaylard Member, of the Carbon Creek Basin. It was demonstrated that facies changes in the Gaylard Member are common both horizontally and vertically. The most conspicuous involve the thick, coarser grained sandstones and conglomerates, some of the thicker mudstone and shale intervals, and some of the major seams of coal.

Ten columnar stratigraphic cross-sections illustrate the facies and facies variations of the Gething Formation between the Smoky River area in the south and the Halfway River area in the north (Figs. 3-10). Like those described in the Carbon Creek Basin, facies variations in other parts of the report area are again best illustrated by the coarser grained sandstones and conglomerates and coal seams, and illustrate the rapidity with which some of these facies grade laterally into finer grained strata or totally disappear.

One example of an abrupt facies variation involving a coarse grained sandstone is illustrated by the 14 m thick, coarse grained sandstone unit below Coal Marker "B" at borehole locality BP 53, which can be recognized and traced toward the southeast and east (Fig. 6). At borehole locality BP 2, the sandstone thins and splits into two units. At Bullmoose Mountain (Sec. 80-1, Fig. 6), the sandstone no longer can be recognized, having graded laterally, over a distance of approximately 3 km, into an interbedded sequence of siltstone, very fine grained sandstone, mudstone and shale. The marker sandstone, however, reappears at the Denison Wolverine QWD 74-03 borehole (Fig. 6), but then again disappears eastward, passing into an interval of thin beds or units of siltstone, sandstone, and mudstone or shale. In the same cross-section (Fig. 6), another example of a conspicuous facies change is illustrated by the thick, pebble conglomerate and conglomeratic sandstone unit near the base of the member at the Denison Wolverine QWD 74-03 borehole. Toward the northwest this coarse clastic facies can be traced to Bullmoose Mountain (Sec. 80-1), but disappears to the west and northwest as documented in the BP 81-13 borehole. Eastward, the conglomerate thins and disappears or splits into a succession of interbedded sandstone, siltstone and mudstone. Similar rapid lateral facies changes can be seen from data plotted in many of the other cross-sections.

In addition to the above examples, sandstone may also be used to illustrate another but more regional facies variation. For example, sandstones in the Pink Mountain–Halfway River area to the north (Fig. 10) form a quantitatively significant facies of the Gaylard Member, commonly interbedded with siltstone and carbonaceous mudstone. The sandstones are thin to thick bedded, quartzose, very siliceous and well indurated. They are clean and generally lighter coloured than those in the south, with only low concentrations of vegetal matter. The sandstones in the vicinity and south of Williston Lake and Peace River (Figs. 3-9) are equally abundant as thin to thick beds, but in this region are noticeably less siliceous, less well indurated, and contain conspicuously higher concentrations of vegetal matter. The contrast in facies between the two areas is attributed to differences in depositional environment.

Figure 25. Fining-upward sequence, sharp based sandstones (tempestites) to coarse siltstones, rhythmically alternating with dark mudstones, in Gaylard Member of west Carbon Creek (Sec. WCC 80-5). Note bioturbated nature of strata and corkscrew-shaped syneresis cracks. ISPG photo. 2473-6.

Rapid facies variations are found in coal seams and coal-bearing intervals. Seams of the Gaylard Member thin, thicken, split or disappear by lateral and vertical gradation into carbonaceous mudstone or shale (Figs. 5-10). A more comprehensive discussion concerning coal and its lateral variation is included later in this report.

Contact relationships

The contact between the Gaylard Member and underlying Cadomin Formation is conformable, abrupt and obvious in most areas, although in some areas it is gradational and in places difficult to assign. Stott (1968, p. 30; 1973) assigned the contact ". . . at the top of the uppermost thick conglomerate which is separated from the basal conglomerates by no more than a few tens of feet of finer sediments." McLean (1977, p. 801; 1982) placed the Gething–Cadomin Formation contact at a level based on the following restrictions for the Cadomin: "Conglomerate and medium- to coarse-grained sandstone beds were included only where separated from the main body of the formation by a thickness of finer-grained sediments less than 1.5 times that of the overlying coarse grained bed." The criteria adopted by the above workers for assigning the Gething–Cadomin contact was found by the writer to be generally applicable. However, because of the interfingering nature of the contact in some regions, as illustrated in Figures 3-10, 12, 16, 26 and 27, the above contact criteria were still sometimes difficult to apply. Accordingly, as noted by Stott (*ibid.*), "The lower contact of the Gething Formation forms no persistent stratigraphic horizon but lies above different conglomeratic beds of the Cadomin from place to place."

In this report, the Gaylard Member–Cadomin Formation contact is placed at a level where massive, generally well indurated, resistant, commonly cliff-forming pebble conglomerate and medium to coarse grained to conglomeratic sandstone of the Cadomin Formation are overlain by, and contrast sharply with, the finer grained sandstones, siltstones, mudstones, and thin to thick seams of coal of the Gaylard Member. At most outcrop localities the contact coincides with a prominent break in weathering profile between the two formations, where Gething strata, because of their generally finer grain size, weather as relatively recessive, talus, grass and tree covered intervals (Figs. 16, 28). At some localities (Figs. 3-10), the Cadomin Formation is gradationally overlain by finer grained sandstone units. These sandstones, however, generally differ from those in the underlying Cadomin Formation. They are conspicuously finer grained, and thinner bedded than the Cadomin sandstones, and commonly contain different sedimentary structures. Accordingly, they are included as the basal facies of the Gething Formation and Gaylard Member. McLean's (1977, 1982) definition may result in the inclusion of some of these sandstones as part of the Cadomin Formation.

In the Belcourt Lake–Dumbgoat Mountain area in the south (Fig. 1), strata of the Cadomin Formation attain a thickness of up to 97 m (Figs. 4, 16). At Dumbgoat Mountain (Sections 82-5 and 82-6 in Figure 1) and Holtslander Creek (Section 79-1 in Figure 1), basal Gething strata are characterized by one or two thick, cliff-forming units of conglomerate and conglomeratic sandstone (Figs. 4, 16). Immediately underlying these cliff-forming conglomeratic facies is a recessive interval composed mainly of carbonaceous and coaly shale, siltstone and occasional thin to thick seams of coal. At the Holtslander Creek locality (Section 79-1 in Figure 4), two relatively thick seams of coal occur in the recessive interval underlying the sandstone and conglomerate facies, and are therefore included as a facies of the Gething Formation. For similar reasons, the thick conglomerate and conglomeratic sandstone units near the base of the Gething at the Pacific BWD 76-4 and Denison 79-08 boreholes (Fig. 5) are also included as facies of the formation.

In the vicinity of Williston Lake at the type section of the Gaylard Member, and at Pink Mountain (Figs. 9, 10), strata of the Cadomin consist mainly of medium to coarse grained sandstone and rare conglomeratic sandstone that are texturally similar to some of the thick sandstone facies in the overlying Gaylard Member (Figs. 26, 27). Because of the compositional and textural similarity and interfingering or gradational relationships of the strata (Figs. 26, 27), the contact can be difficult to assign. However, it is

Figure 26. Contact and lithological relationships between the Cadomin Formation and Gaylard Member, at type locality of Gaylard Member and Gething Formation, west side of Peace River Canyon (Dinosaur Lake). Note interfingering of thick, light weathering distributary channel sandstones and dark, recessive weathering, overbank siltstones. Gaylard Member (Gy); Cadomin Formation (Cd). ISPG photo. 2065–33.

Figure 27. Contact and lithological relationships between the Cadomin Formation and Gaylard Member, at type locality of Gaylard Member and Gething Formation, east side of Peace River Canyon (Dinosaur Lake). Note epsilon crossbedding above marker sandstone near base of Gaylard Member. Gaylard Member (Gy); Cadomin Formation (Cd). ISPG photo. 2065–29.

placed on the basis of contrast, where the thicker bedded and coarser grained sandstones change to the finer grained, thinner bedded, slightly more carbonaceous sandstones of the Gaylard. In the area of Pink Mountain (Fig. 1), sandstones in the two formations are compositionally similar, resulting in difficulty in assigning a consistent lithological contact. Accordingly, the contact must be assigned arbitrarily (Fig. 10), or the formations may be combined as a single undifferentiated unit of the Gething, as shown by Stott (1973).

Contact relationships with the overlying Bullmoose Member, or Moosebar and Bluesky formations of the Fort St. John Group range from abrupt and conformable to possibly disconformable. Between the Burnt-Sukunka rivers area in the north, and the Monkman-Stony Lake area in the south, Gaylard strata are abruptly but conformably overlain by marine to brackish marine strata of the middle Gething Bullmoose Member (Figs. 5-7, 15). The contact is placed where the thin to thick bedded, coal-bearing rocks of the Gaylard grade abruptly upward into a lithologically different, mainly thin bedded succession of generally coal-free siltstone, sandstone, mudstone and shale assigned to the Bullmoose Member (Figs. 5-7). On this basis, the contact is placed at the top of a thick bedded, fine to medium grained sandstone that forms the uppermost facies of the Gaylard Member (Figs. 5-7, 15). The capping sandstone of the Gaylard also forms part of a thin, coarsening-upward profile. The contact criteria designated and described in the area result in most coals and coaly mudstones of the Gething Formation being confined to either the Gaylard or Chamberlain members.

Figure 28. Contact and lithological relationships between the Cadomin and Gething formations near Mount Gorman. Note cliff-forming character of Cadomin Formation and general recessive character of Gething Formation. Gething Formation (Gt); Cadomin Formation (Cd); Gorman Creek Formation (Gc). ISPG photo. 2470-8.

In most Foothills areas north of the Burnt and Sukunka rivers and Bullmoose Mountain, the Gaylard stratigraphic interval is abruptly overlain by marine strata of the Moosebar or Buckinghorse formations (Figs. 8-10). It should be noted that, in the Hasler-Brazion creeks area south of Pine River, the Gething Formation is overlain by strata similar in character to those of the Bullmoose Member of the Burnt-Sukunka rivers area to the southeast. Moreover, a thin unit of fine to very fine grained sandstone with interbeds of siltstone and mudstone was recorded from near the top of the Gulf Goodrich 81-06 well (Figs. 7, 10b). This thin sandstone lithofacies unit (4.5 m thick) represents a probable remnant tongue of the Chamberlain Member to the southeast. However, because of its thin development and fine grained coal-free character, the strata are included as part of the Moosebar Formation. Accordingly, the Gething-Moosebar contact is assigned to this lower level (Fig. 7). In the Plains area to the east and northeast, the Gaylard Member is overlain by sandstones and shales of the Bluesky Formation of the Fort St. John Group (Pugh, 1960).

In the Foothills north of the Burnt and Sukunka rivers, including the type section of the Gaylard Member, the contact between the Gaylard Member and the Moosebar and Buckinghorse formations is placed immediately below a very argillaceous, dark grey, glauconitic, sandy, quartzose mudstone to conglomeratic argillaceous sandstone or quartz-chert pebble conglomerate, which occurs at the base of the Moosebar and Buckinghorse formations. This generally resistant weathering marker facies is dark grey to black and ranges from a few centimetres up to two metres in thickness. The conglomerate is composed of well rounded quartz, quartzite, and chert pebbles and cobbles-some of which are up to 10 cm in diameter, "floating" in a matrix of either sandy mudstone or argillaceous quartzose sandstone. The dark grey mudstone, sandstone or conglomerate facies contrasts with the underlying strata, resting abruptly on lighter coloured quartzose sandstones or coaly, carbonaceous mudstones and siltstones of the Gaylard Member.

In the Pine and Peace rivers area (Figs. 8, 9), the base of the Moosebar Formation is marked by conglomeratic, sandy mudstone to sandstone that abruptly overlies dark grey, carbonaceous siltstone and shale containing abundant coaly and vegetal matter. However, at Crassier Creek, north of Pine River, the contact between the Gaylard Member and Moosebar formation is unusual. Here, a light grey weathering conglomerate and conglomeratic sandstone unit, 14 m thick, occurs between the dark grey marine strata of the Moosebar Formation and the typical lighter grey, more resistant weathering, coal-bearing strata of the Gething Formation. The conglomerate and sandstone unit is thick bedded, resistant weathering, and is composed of well rounded, poorly sorted, quartzitic sandstone, chert and lithic pebbles, and cobbles averaging approximately 5 to 8 cm in diameter, in a matrix of coarse grained quartz sandstone. The conglomerate is both matrix and clast supported. Kilby (1984b), Oppelt (1986) and others included the unusual facies as part of the basal Fort St. John Group and as an equivalent to the Bluesky Formation. However, its light weathering character, and the conspicuous absence of glauconite, argillaceous matrix and cement, may suggest an affinity to strata of the Gething Formation. A similar, thick, pebble to cobble conglomerate facies has been reported by Pugh (1960), Legun (1984c) and others, between the marine Moosebar and nonmarine Gething formations on Butler Ridge north of Williston Lake. At this locality the conglomerate has again been interpreted as part of the Fort St. John Group.

In the subsurface of the Plains area to the east, Gaylard strata are abruptly and probably conformably overlain by thin to thick bedded units of glauconitic quartz sandstone (Figs. 7, 9). The sandstones are illustrated in the easternmost boreholes shown on Figure 9 and the three easternmost boreholes of Figure 7. The contact is placed at the base of a relatively thick succession of coal-free, quartz sandstones that underlie strata typical of the Moosebar Formation. In the Plains area, this distinctive sandstone sequence is called the Bluesky Formation. As can be seen at some localities shown in Figures 7 and 9, the Bluesky sandstones are underlain by an additional clean, quartz sandstone facies containing interbeds of siltstone, mudstone and shale with no obvious coal. This facies is in turn underlain by coal and coaly mudstone, siltstone and sandstone typical of the Gething Formation. The coal-free sandstone, siltstone and mudstone lithofacies which occurs below the main Bluesky Formation, may be included by some workers as an additional facies of the Bluesky Formation (Oppelt, 1986). Additional work is necessary to resolve the complex stratigraphic relationships between the Moosebar, Bluesky and Gething formations.

Age and correlation

Until recently, most fossil assemblages collected from the Gething and strata equivalent to the Gaylard Member were not sufficiently time sensitive to date the strata with precision. As noted above, earlier reports by Stott (1968, 1973) Chamney (1973) and others, in which the microfauna, microflora, macrofauna and macroflora of the Gething Formation were described and discussed, indicated an age for the Gething Formation which ranged from Hauterivian to earliest Albian. Most of these collections were obtained from strata herein included as part of the Gaylard Member. For example, Duff and Gilchrist (1981) identified several bivalves from these strata, but no specific ages were assigned to the genera. Gibson (1985a, p. 4) recovered two bivalves from mudstones of the Gaylard Member in the Carbon Creek Basin. The genera, identified by J.A. Jeletzky of the Geological Survey of Canada, included *Aucellina aptiensis* (d'Orbigny) Pompeckj and *Aucellina caucasica* (Abich), which he interpreted as indicating an Aptian age for part of the Gething succession in the area. However, on other continents, these species have been recorded from strata as young as Early Albian (Kauffman, 1979). Other bivalves, obtained from the same area, included *Unio* (*Elliptio*) cf. *biornatus* McLearn, for which an Aptian age was suggested by Jeletzky.

Several Gaylard Member samples from the Carbon Creek and other regions of the report area were submitted for analysis to A.R. Sweet (microflora), D.J. McIntyre (microflora, dinoflagellates), N. Ioannides (dinoflagellates) and J.H. Wall (microfauna) of the Geological Survey of Canada, in the pursuit of new information that might be used in dating the strata more precisely (Appendix 2). Unfortunately, most palynological and dinoflagellate genera had been subjected to a relatively high degree of carbonization, so that the spores and dinoflagellates were too poorly preserved for accurate identification. Where the specimens were identifiable, the population contained only long ranging species. The analyses and results did, however, provide new information on the depositional environments. Results from the microfossil analyses proved rewarding. Samples analysed from an interval ranging from 11 to 16 m below the top of the thick, marker sandstone capping the Gaylard Member in the Sukunka-Burnt rivers area (Figs. 7, 9, 15), yielded a microfauna that included *Gaudryina nanushukensis* Tappan, *Globulina lacrima canadensis* Mellon and Wall, *Serovaina loetterlei* (Tappan), and *Quadrimorphina albertensis* Mellon and Wall, all of which, according to Wall, form part of the *Gaudryina nanushukensis* Zone and the *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone, which are of late Early Albian age. The discovery of this microfaunal zone within the upper part of the Gaylard Member and in the overlying Bullmoose Member now provides a new and more precise upper age limit for Gething strata. In the same area, several other samples from the Gaylard yielded foraminifers, freshwater charophytes, ostracodes, gastropods and sponge spicules, for which ages ranging from late Aptian(?) to Albian are suggested.

Because of the interfingering stratigraphic relationship between lower Gething and Cadomin Formation strata in the southern part of the report area, coupled with the Hauterivian-Barremian age suggested by Stott (1968, 1973) for the Cadomin Formation, it may be suggested, therefore, that strata of the lower Gething and Gaylard Member range in age from possible Hauterivian to late Early Albian. For a more detailed discussion and listing of fossils and fossil collections from strata equivalent to the lower Gething Formation and Gaylard Member, and their suggested age assignments and relationships, the interested reader is referred to reports by Stott (1968, 1973), Duff and Gilchrist (1981), and the appendices of this report.

The Gaylard Member can be easily recognized and correlated throughout most regions of the report area where strata of the marine Bullmoose Member can be readily identified, or where it can be demonstrated that strata of the Chamberlain Member are absent. However, as noted and discussed above, correlation with strata south of the Monkman-Stony Lake area is difficult and generally not reliable without detailed microfossil analysis. Accordingly, the Gething Formation remains undifferentiated in that region.

Sedimentary and biogenic structures

Primary sedimentary structures are common in the Gaylard Member, the most conspicuous of which consist of small- to medium-scale festoon crossbeds, planar-tabular crossbeds and current, ripple and ripple-drift lamination (Figs 29-33). Flaser bedding is conspicuous in some of the finer grained ripple laminated sandstones in the Pine and Peace river areas (Gibson, 1985a). Festoon crossbedding is the predominant large-scale structure, and is confined mainly to the coarser grained and thicker bedded sandstones. The size or scale of crossbedding appears to be related to the sediment grain size of the host rocks. For example, the coarsest grained sandstones and conglomerates contain conspicuously larger scale crossbeds; in contrast, the finer grained sandstones are characterized by noticeably smaller scale crossbeds (Fig. 31).

In the Sukunka River and Bullmoose Mountain areas and at one locality in the Monkman area (Figs. 5-7), low-angle crossbeds and horizontal planar lamination occur in the fine to medium grained sandstones capping the member. Well developed ripple crosslamination occurs in most of the finer grained sandstones and some of the coarser grained siltstones, particularly the thin bedded, fining-upward sandstone units forming part of the cyclically bedded sandstone-siltstone-mudstone facies assemblage (Figs. 31-33). Ripple-drift or climbing-ripple lamination are conspicuous in some of the thicker

Figure 29. Epsilon crossbedding in distributary channel sandstone of the Gaylard Member at Bennett Dam overflow spillway. Part of the Gaylard section illustrated in Figure 20. ISPG photo. 2396-14.

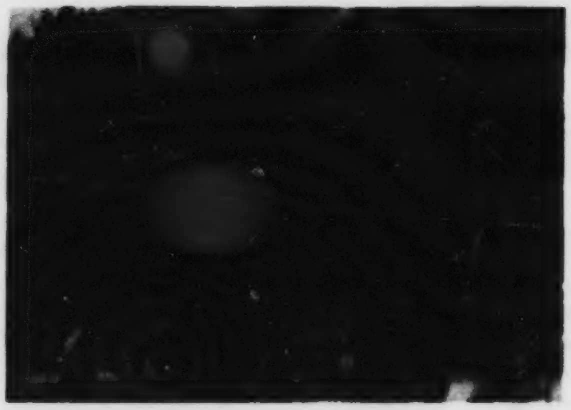


Figure 30. Deformed medium-scale crossbedding in distributary channel sandstone of the Gaylard Member at Bennett Dam overflow spillway. Part of the Gaylard section illustrated in Figure 20. ISPG photo. 2065-43.

sandstone units of the Williston Lake area, commonly occurring in the upper third of some of the thicker bedded facies. Mudstone flasers occur in some of the densely ripple-laminated sandstones of the wavy to lenticularly bedded, cyclical sandstone-siltstone-mudstone facies (see Gibson, 1985a).

Convolute laminae are common in both sandstone and siltstone units capping many of the fining-upward sandstone facies. Cut-and-fill structures and small-scale, bulbous load casts were noted at the base of some of the thicker sandstones, particularly those underlain by finer grained clastics such as siltstone or mudstone. North of the Burnt-Sukunka rivers area, many mudstones and siltstones are characterized by subaqueously formed syneresis cracks (Donovan and Foster, 1972; Collinson and Thompson, 1982). These unusual sedimentary structures display a vertical corkscrew or burrow-like appearance (Figs. 22, 34, 35). They consist of small vertical to subvertical corkscrew projections of light grey, very fine grained sandstone or siltstone that extend downward into dark grey mudstone to shale. They rarely exceed 1.3 cm in width (top) or 2.5 cm in length. The corkscrew or enterolithic character of the cracks results from compression by the overlying strata. Syneresis cracks were also recorded in Gaylard strata south of the Burnt and Sukunka rivers, but in lesser concentrations.

Figure 31. Small-scale ripple crossbedding in crevasse splay sandstone of the Gaylard Member at Bennett Dam overflow spillway. ISPG photo. 2065-22.

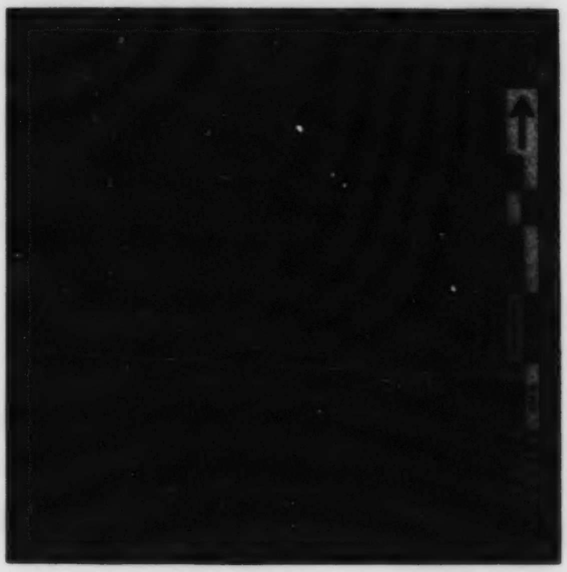


Figure 32. Small-scale ripple crosslamination in Gaylard Member, Carbon Creek Basin. ISPG photo. 1016-22.

Figure 33. Stacked ripple lamination in Gaylard Member, Carbon Creek Basin. ISPG photo. 1016-28.

Vertical, subvertical and horizontal burrows and other ichnogenera occur throughout the finer grained facies of the member, although they are most common and conspicuous in cores from the Williston Lake area to the north (Figs. 22, 24, 25, 36; Gibson, 1985a). The burrows are most conspicuous and best developed in the rhythmically bedded, fine grained sandstones, siltstones and mudstones. In the southern part of the report area they occur sparingly throughout the Gething succession, with the exception of the upper Gladstone Formation in the Grande Cache area of Alberta, where they are abundant (Fig. 3). Most burrows appear to be of the *Skolithos* or *Planolites* type with burrow diameters ranging from 5 to 10 mm. Dinosaur tracks were recorded in rippled sandstones at Peace River Canyon (Fig. 37).

Rhizoliths or root structures occur in many of the finer grained sandstones and siltstones, particularly those associated with paleosols, coal seams or carbonaceous mudstones and siltstones (Figs. 38, 39).

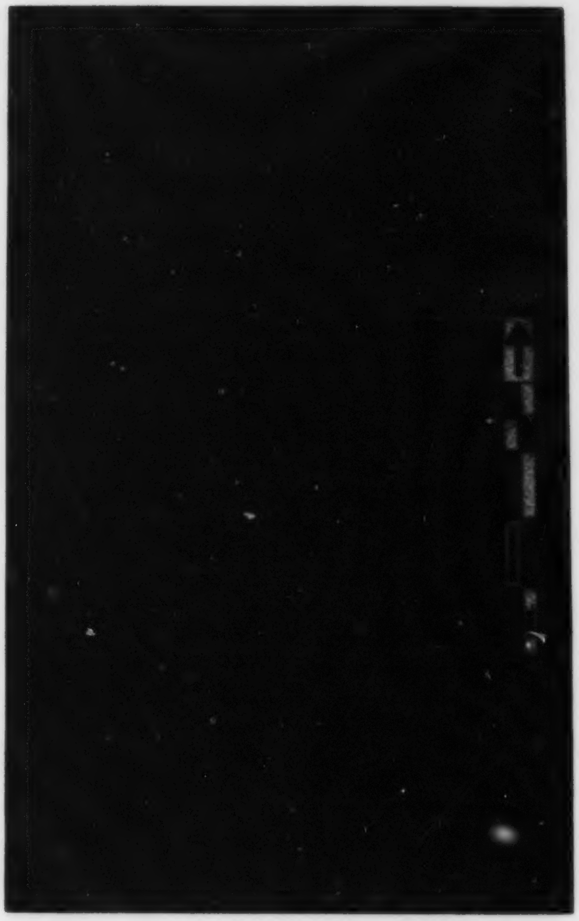


Figure 34. Syneresis cracks in core of Gaylard Member from Carbon Creek Basin. Note sharp based, fining-upward, ripple laminated to micro-crossbedded sandstone tempestites or storm pulse layering. Planolites-like traces occur in the dark grey siltstone to mudstone. ISPG photo. 2473-4.

Figure 35. Plan view of syneresis cracks in wave rippled sandstone of the Gaylard Member, Peace River Canyon (Dinosaur Lake). ISPG photo. 2065-36.

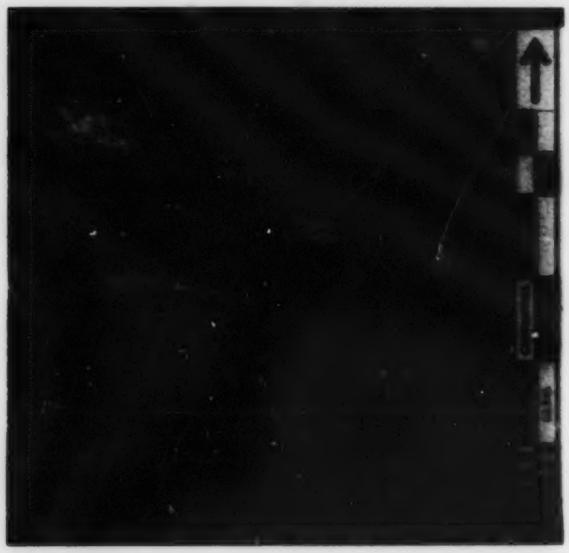


Figure 36. Bioturbated siltstone and sandstone of the Gaylard Member, near Peace River Canyon. ISPG photo. 2473-12.

They form vertical, carbonaceous, black films, up to 15 cm long and 1 to 5 mm wide.

Large and small wood moulds and casts occur near the base of some major sandstones in outcrops at Bullmoose Mountain, Dumbgoat Mountain and in the area of Grande Cache. These structures are flattened to lenticular in cross-section, and elongate, straight or curved in plan, displaying, in part, growth or bark patterns. In core, they may appear as vitreous coal-spars or thin coal lenses, commonly stacked in the lower facies of the major sandstones (Fig. 18). Silicified wood was noted in fine grained sandstone at Peace River Canyon (Fig. 40).

Figure 37. *Large herbivorous dinosaur track in ripple sandstone of the Gaylard Member, Peace River Canyon (Dinosaur Lake). ISPG photo. 2065-35.*

Figure 38. *Coaly and carbonaceous rootlets in floodplain sandstone of the Gaylard Member, at Bennett Dam overflow spillway. Same locality in Figure 20. ISPG photo. 2065-2.*

Figure 39. *Close-up of coaly and carbonaceous rootlets in floodplain sandstone of the Gaylard Member, at Bennett Dam overflow spillway. Same locality as Figure 20. ISPG photo. 2065-3.*

Figure 40. *Silicified log in very fine grained sandstone of the Gaylard Member, Peace River Canyon (Dinosaur Lake). ISPG photo. 2470-4.*

BULLMOOSE MEMBER

Definition, distribution and thickness

The Bullmoose Member of the Gething Formation, a facies equivalent of the Moosebar Formation of the Fort St. John Group, occupies the stratigraphic interval bounded by the Gaylard Member below, and the economically important, coal-bearing strata of the Chamberlain Member above (Figs. 2, 12, 13). In outcrop, the strata are recessive weathering and are generally talus, grass or tree covered, which contrasts with the underlying, slightly more resistant weathering strata of the Gaylard Member, and the very conspicuously resistant weathering, massive, and generally cliff-forming strata of the Chamberlain Member (Figs. 15, 41, 42). In core, the Bullmoose is distinguished by its generally thin bedded, fine grained and coal-free character (Figs. 43, 44).

Strata equivalent to the Bullmoose Member were first recorded as an unusual, coal-free, marine-like succession within the Gething Formation of the Sukunka River–Bullmoose Mountain area, by geologists of B.P. Canada Limited, an observation brought to the attention of the writer at the beginning of this investigation in 1979. As part of a correlation study of Lower Cretaceous coal measures in the Peace River Coalfield, Duff and Gilchrist (1981), using fossils and a distinctive coarsening-upward geophysical log profile, traced the distribution of the Bullmoose facies in the vicinity of and south of the Sukunka and Burnt rivers to approximately the area of Quintette Mountain (Fig. 1). They informally named the succession the "Gething marine tongue" (Fig. 2). No detailed information was provided on the lithology, unit contacts or lithofacies relationships. Legun (1984a, 1985a), Kilby (1984b, 1985) and Oppelt (1986) have discussed some aspects of the marine unit including its distribution and lithological character in the subsurface of the Foothills and Plains.

Strata of the Bullmoose Member are well exposed at Bullmoose Mountain and have been penetrated by several coal and petroleum exploration boreholes in the adjacent area. The designated type section at Bullmoose Mountain (Figs. 1, 6, 15, 41, 42; UTM 596300E, 6116500N; topographic map of Bullmoose Creek, NTS 93 P/3, 1:50 000 scale) illustrates all lithofacies typical of the interval and, as noted above, is readily accessible by 4-wheel drive vehicle or by helicopter from Chetwynd. The section is illustrated in Figures 6, 15, 41 and 42, and has been described by Stott (1973, p. 220). A detailed description of the member is included in Appendix 3. Core from borehole BP 53 illustrates facies typical of the unit and the detailed contact relationships (Figs. 6, 7, 43; UTM 588170E, 6120861N; topographic map of Sukunka

Figure 41. Contact and lithological relationships of the Bullmoose and Chamberlain members and Moosebar Formation at Bullmoose Mountain. Figure is a continuation of the section shown in Figure 15. Bullmoose Member (Bm); Chamberlain Member (Ch); Moosebar Formation (Mb). ISPG photo. 2649-3.

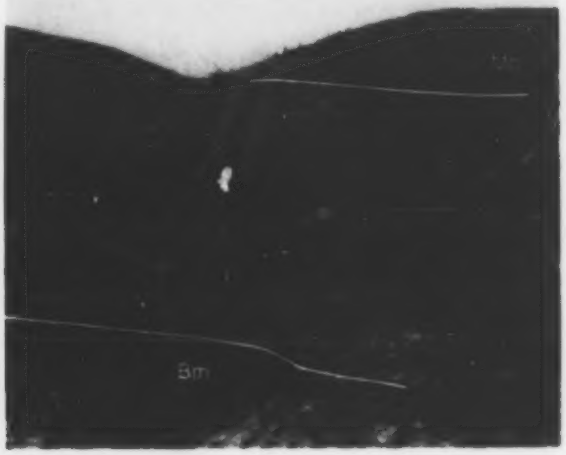


Figure 42. Cliff-forming sandstones of Chamberlain Member at Bullmoose Mountain. Note coarsening-upward character and transition from strata of the Bullmoose Member to those of the Chamberlain. Bullmoose Member (Bm); Chamberlain Member (Ch); Moosebar Formation (Mb). ISPG photo. 2649-2.

River, NTS 93 P/4, 1:50 000 scale), and BP 2 (Fig. 6; UTM 593700E, 6114900N; topographic map of Sukunka River, NTS 93 P/4, 1:50 000 scale). In addition, a gamma ray and density log illustrating the general coarsening-upward character of the Bullmoose Member has been included with the log of borehole BP 53 (Fig. 7). The core may be examined at the core storage and examination facilities of the Ministry of Energy, Mines and Petroleum Resources, Charlie Lake, British Columbia.

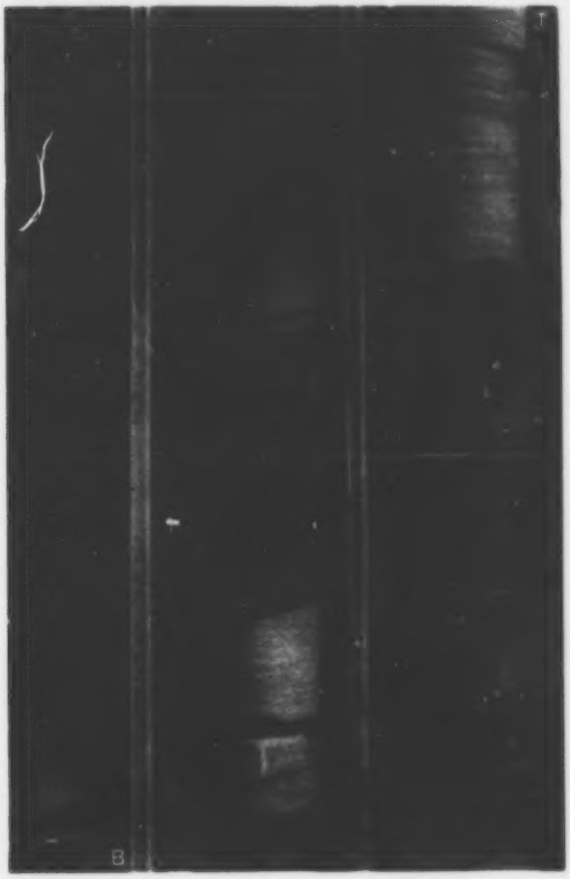


***Figure 43.** Core of the shoreface transition facies of the upper Bullmoose Member at borehole BP 53. Note fining-upward, sharp based, light weathering, very fine grained sandstone containing hummocky crossbedding, alternating with darker weathering, bioturbated siltstone and mudstone, and large burrow trace in centre of photograph. Thin bedded sandstones represent probable tempestites, or storm pulse deposits, debouching into a shallow marine coastal environment. Note similarity to facies of Bullmoose Member in Figure 44. Top of core (T). Bottom of core (B). ISPG photo. 2470–1.*

Bullmoose strata have a limited distribution (Figs. 5, 7, 12, 13). The succession is best developed in the Burnt-Sukunka rivers area (Fig. 7). North and northeast of this area the strata thicken and grade laterally into, and become part of, the Moosebar Formation (Fig. 7). A similar relationship occurs toward the north and northwest in the area of Brazion and Hasler creeks (Fig. 7). For example, the Bullmoose at localities BP 53, BP 2 and at Bullmoose Mountain is

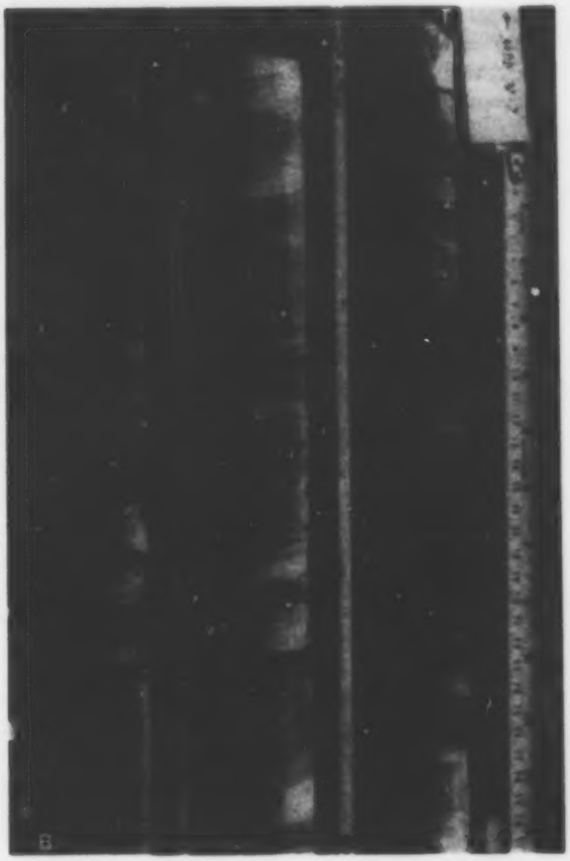


***Figure 44.** Rhythmic alternations of light weathering, very fine grained sandstone to siltstone, and dark weathering mudstone in the Bullmoose Member at the Pacific Monkman 78-7 well. Note fining-upward and light weathering character of sandstone deposited by storm pulses as tempestites, and general bioturbation of strata. Top of core (T). Bottom of core (B). ISPG photo. 2470–16.*

abruptly overlain by thick sandstones and the economically important coal seams of the Chamberlain Member (Figs. 6, 7). At the Getty Gwillim C-27-E well, 17.5 km north of Bullmoose Mountain, the Bullmoose Member grades upward into a sequence of fine to very fine grained sandstone and siltstone with no evident seams of coal (Fig. 7). This sandstone lithofacies is interpreted as a tongue or facies of the Chamberlain Member. Accordingly, the underlying strata (76 m) are included as part of the Bullmoose Member. At the Phillips Puggins C-40-L well, 42 km northeast of Bullmoose Mountain, the conspicuous sandstone facies of the Chamberlain Member found in other areas does not occur (Fig. 7). Instead, the interval is occupied by mainly mudstone and siltstone, which is included in the Moosebar Formation in this report. Accordingly, the contact between the Moosebar Formation and top of the Gething Formation in this region is placed at a stratigraphically lower level, corresponding with the top of the Gaylard Member (Fig. 7). A similar relationship occurs in the Brazion and Hasler creeks area to the northwest. A thin sandstone facies occurs near the top of the Gulf Goodrich 81-06 borehole (Fig. 7). This facies, like that at the Phillips Puggins C-40-L well, is assigned to the Moosebar Formation.

Bullmoose strata can be recognized and traced southward as far as the Monkman-Stony Lake area (Figs. 5, 10b, 42, 45). However, toward the east the Bullmoose Member is not as evident. Thick sandstones and significant concentrations of coal occur in the upper third of the Gething Formation in three wells shown in Figure 5b. The typical coarsening-upward stratigraphic profiles, characteristic of the Bullmoose Member elsewhere to the west, are not readily evident in this area. The base of the thick sandstone units, 55 to 85 m below the top of the three wells, may represent the contact between the upper and middle members. The silty shale units and solitary thin sandstone unit, approximately down to the level of the first underlying coal in the Quasar Murray A-89-E well, may represent strata equivalent to the Bullmoose Member. South and southeast of the Monkman-Stony Lake area (Figs. 3-5), the Bullmoose Member can no longer be recognized with assurance. The strata are assumed to have graded laterally into either the lower and/or upper, undifferentiated Gething Formation (Figs. 10b, 13). Oppelt (1986), has recorded marine strata within the Gething Formation near Wapiti Lake, in a facies which he interpreted as the Bluesky Formation. These strata may, however, represent a remnant of the Bullmoose Member.

The Bullmoose Member ranges in thickness from a maximum of 77 m at the BP 53 borehole (Fig. 7), to a minimum of 1.5 m at the Pacific MDD 79-18 borehole south of Quintette Mountain (Fig. 5a). The thickness variation illustrates a prominent thinning trend along strike toward the south and southeast. North, northwest, east and northeast of the Burnt and Sukunka rivers area, the Bullmoose interval thickens at the expense of the overlying Chamberlain Member, to such an extent that the Bullmoose becomes part, or a facies, of the Moosebar Formation (Figs. 7, 12).

Figure 45. Lithologies and contact relationships of the Bullmoose and Chamberlain members in the Monkman-Stony Lake area, Petro-Canada DDH 81-04 well. Note dark grey mudstone tongue in light grey sandstone of Chamberlain Member. Top of core (T). Bottom of core (B). ISPG photo. 2674-27.

Lithology

The Bullmoose Member consists of an interbedded, interlaminated succession of predominantly marine sandstone siltstone, mudstone or shale (Figs. 3, 6, 43-46). The strata generally form part of a major coarsening-upward sequence (Figs. 41, 42), which in turn is charcterized in the Sukunka River area by up to three secondary or minor coarsening-upward profiles (Figs. 6, 7). In contrast to the Gaylard and Chamberlain lithofacies, Bullmoose strata contain only two distinct lithofacies or lithofacies assemblages. The dominant, and most conspicuous consists of rhythmic fining-upward, graded units of sandstone to siltstone and mudstone or shale. The other stratal type consists of fine to coarse grained sandstone, locally conglomeratic, which forms the top of the secondary, coarsening-upward sequences.

Rhythmic sandstone-siltstone-mudstone facies assemblage

The rhythmic sandstone-siltstone-mudstone (or shale) facies of the Bullmoose Member, a facies similar to the sandstone-siltstone-mudstone facies in the underlying Gaylard Member, consists of fining-upward, thin, wavy to lenticular beds or isolated lenses of light to medium grey, very fine grained sandstone to siltstone, grading upward into and alternating with darker grey, thin to thick beds or units of mudstone or shale (Figs. 43, 44). In outcrop, the strata form resistant and recessive weathering, thin to thicker bedded couplets. The facies assemblage may be described as a carbonaceous, argillaceous, generally calcareous mudstone, rhythmically interspersed with thin fining-upward beds of sandstone and siltstone. A typical couplet consists of a sharp based, light to medium-dark grey, very fine grained sandstone to sandy siltstone (passing upward into darker grey, generally calcareous, sandy siltstone), gradationally overlain by dark grey mudstone to shale, the main lithotype of the Bullmoose Member (Figs. 43, 44). Most graded beds are thin, but may be up to 24 cm thick, particularly in the upper transitional phase at the top of the primary coarsening-upward sequence. The mudstone or shale is most prevalent at the base of the secondary and major coarsening-upward sequences (Figs. 6, 7), decreasing in concentration toward the top. The mudstone is very carbonaceous-argillaceous, very silty and locally, very calcareous. Thin to thick, lighter grey, subparallel to wavy, lenticular siltstone to sandstone laminae are common (Figs. 43-46). In core, the mudstone contains incipient brownish grey to orange-brown, irregularly shaped, sideritic ironstone banding and concretions, thin pyrite laminae, pyrite rosettes and, locally, small pyrite-filled burrows. Only the concretions and burrows are evident in outcrop. In addition, pelecypods are locally conspicuous. The more argillaceous mudstones display a distinct subconchoidal fracture. The graded, coarser grained sandstones occur with increasing frequency and increasing unit thickness toward the top of each coarsening-upward assemblage (Fig. 42). The grain size of the sandstone is such that it is difficult to differentiate sandstone from coarse siltstone without a laboratory analysis, and, therefore, some facies identified as sandstone may in fact be siltstone. The thin bedded sandstone is quartzose, calcareous and/or dolomitic. In the Monkman–Stony Lake area to the south, the rhythmic sandstone-siltstone-mudstone facies assemblage can still be recognized as a

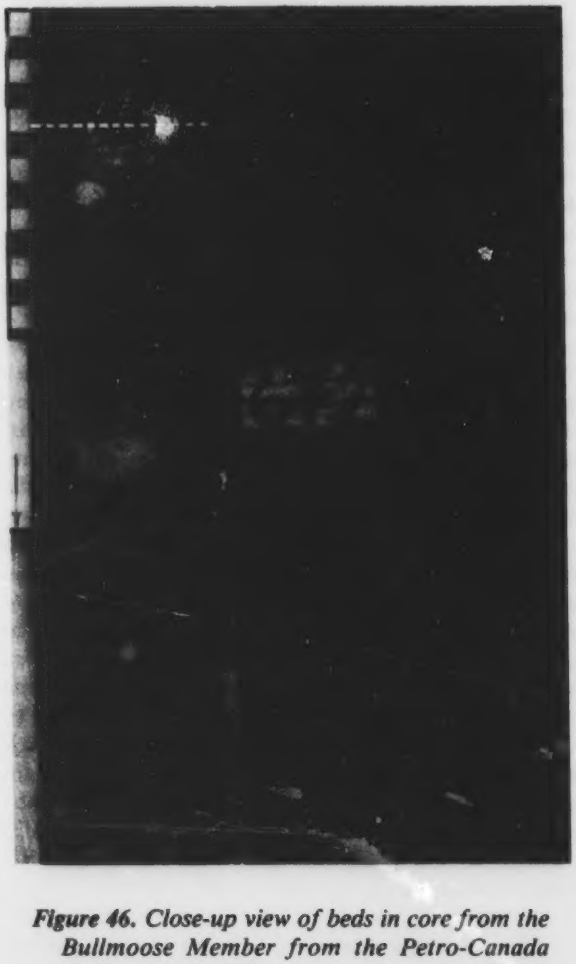


Figure 46. Close-up view of beds in core from the Bullmoose Member from the Petro-Canada DDH 81-04 well. Note the transgressive sandstone at base, underlain by coal (removed). ISPG photo. 2674–29.

conspicuous facies of the Bullmoose Member (Figs. 45, 46). The rhythmic facies occurs "sandwiched" between thick, fine to coarse grained sandstone units of the Gaylard and Chamberlain members. The strata display wavy to lenticular bedding similar to that in the thicker section localities to the north. However, plant fragments or phytoclasts and rare coalspars occur in some of the more sandy and coarser grained facies.

Sandstone

Sandstone, in units approximately 1 to 4 m thick, forms a conspicuous but quantitatively insignificant lithofacies of the Bullmoose strata. Up to four sandstone units have been recognized, although at most localities only one or two coarser grained sandstone units were noted (Figs. 6, 7). In outcrop, the sandstone is resistant and contrasts with the more recessive, rhythmically bedded, finer grained facies. The sandstone commonly "caps" the secondary coarsening-upward units, or forms a thin transgressive sandstone or pebble "lag" near or at the base of the Bullmoose succession (Figs. 5-7, 45, 46). The sandstone is medium to greenish grey, weathering rusty orange to orange-brown. It ranges from fine to coarse grained, to locally conglomeratic, and is very quartzose, cherty, calcareous and glauconitic, the last component commonly imparting a greenish hue to the strata. Thin sections of two coarse grained samples (from the BP 2 and BP 53 boreholes, shown in Figure 6), indicate a composition of well sorted, well rounded to subrounded grains of light and dark grey chert, brownish grey to phosphatic chert, semi-opaque silicified argillite, quartz, and quartzite; and lesser grains of subrounded to angular dolomite, limestone and glauconite; in a cement of silica and rare calcite. In the Monkman–Stony Lake area to the south (Fig. 5), only one thin sandstone was recognized. The sandstone is conglomeratic and occurs at the base of the member (Figs. 45, 46). The pebbles are well rounded, up to 5 cm in diameter, and occur in a matrix of fine to coarse grained quartz and chert sandstone. Glauconite was not observed. In addition, orange-brown ironstone concretions, up to 20 cm in diameter, and dark grey, angular, mudstone rip-up clasts were noted in the thick Bullmoose Member sandstone at Bullmoose Mountain (Fig. 6).

Facies variations

Facies variations are rare, with the exception of the occurrence and distribution of the coarser grained sandstones (Figs. 5-7). For example, at Bullmoose Mountain and the BP 2 borehole (Fig. 6), only one medium to coarse grained sandstone occurs in the succession. At the BP 53 borehole (Fig. 6), Bullmoose strata contain three thin, fine to medium grained sandstone units. At the Getty Gwillim C-27-E well to the northeast (Fig. 7), the member also contains distinct but much finer grained sandstone units. In the Monkman–Stony Lake area the Bullmoose thins, becoming more carbonaceous and locally containing conspicuous plant debris and thin beds of pebble conglomerate (Fig. 5).

Contact relationships

The contact with the overlying Chamberlain Member is gradational although generally abrupt. In the area of Burnt and Sukunka rivers the contact is placed at the base of a thick, fine to coarse grained, quartz sandstone facies that abruptly but conformably overlies the darker grey, recessive, rhythmic, thin bedded sandstone, siltstone and mudstone of the Bullmoose Member (Figs. 5-7, 15, 41, 42). In outcrop (Bullmoose Mountain, Sec. 80-1, Fig. 6), the contact coincides with a prominent change in weathering profile between the recessive, generally talus covered strata of the Bullmoose Member and the overlying more massive, thick bedded, cliff-forming strata of the Chamberlain Member (Figs. 15, 41, 42).

At the BP 2 borehole (Fig. 6), the upper contact of the Bullmoose is gradational. Here, the base of the Chamberlain Member consists of a fine to medium grained sandstone, 21 m thick, the lower 8.5 m of which contain two thin (up to 0.5 m thick) units of thin and wavy to lenticularly bedded, very fine grained sandstone, siltstone and mudstone—facies typical of the underlying Bullmoose Member. Because of the predominance of sandstone in the unit, the thin bedded strata are included as part of the Chamberlain Member.

At the Getty Gwillim C-27-E well, to the northeast, the contact is again gradational, and is placed at the base of a thick, fine to very fine grained sandstone, 23.4 m below the base of the Moosebar Formation (Fig. 7).

In the Monkman–Stony Lake area to the south, where the Bullmoose Member is thin (Figs. 5, 10b, 45), the contact with the Chamberlain Member is not as readily apparent as it is in the north. However, it is placed at the base of the first thick sandstone above the darker grey, thin bedded strata typical of the Bullmoose Member. Because of the relatively thick sandstone at the top of the Gaylard Member at some localities in the southern area, and combined with the thinness of the Bullmoose Member in the same area, caution must be exercised in assigning the contact (Figs. 5, 10b). As noted above, because of lateral facies changes and lack of core and microfossil analyses, strata of the Bullmoose Member are difficult to recognize in petroleum exploration wells (Fig. 5b). The contact with the Chamberlain Member has not been established, although one could assign it to the base of the first thick sandstone (e.g., Kerr McGee Grizzly a-49-H well) or sandstone-dominant interval (e.g., Texex Flatbed a-21-F well) within the upper half of the Gething Formation (Fig. 5b). At the outcrop locality of Five Cabin Creek (Fig. 5), strata of the Bullmoose Member, although probably present, went unrecognized. The contact is tentatively assigned, as shown, to include the recessive covered interval (Fig. 5).

The contact between the Bullmoose and Gaylard members is conformable and ranges from abrupt to gradational as previously discussed.

Age and correlation

Macrofossils, although relatively common, have to date been of limited value for dating or correlating the strata. They have, however, proved useful in identifying and delineating the marine environment in which the Bullmoose sediments were deposited. Several specimens of *Pecten* (*Entolium*) cf. *irenense* McLearn were recovered from the upper half of the Bullmoose Member at Bullmoose Mountain (Fig. 6). Jeletzky identified the specimens and assigned a Cretaceous age, based on the fact that *Pecten* (*Entolium*) *irenense* is common in the Aptian-Albian marine formations of the Canadian Western Interior region. However, the pectinids from Bullmoose Mountain, when compared to *Pecten irenense* from the Western Interior region, do not necessarily suggest an age as specific as the Aptian-Albian. He further commented that "there is a number of other longer ranging Cretaceous (and even Jurassic) *Pecten* (*Entolium*) species (e.g. *P.* (*E.*) *orbicularis* d'Orbigny) which are for all practical purposes indistinguishable from *P.* (*E.*) *irenense* McLearn." Duff and Gilchrist (1981) recorded *Entolium irenense* from several cored intervals in the Sukunka River area, from strata herein included as part of the Bullmoose Member; however, no age was assigned to the specimens. In addition to the *Entolium* macrofossils they also recovered *Murraia*? sp., *Protocardia* sp., *Spherium* sp., and *Yoldia kissoumi*.

In contrast to the macrofossils, microfossil collections proved extremely useful for dating and correlating the strata. Several core and outcrop samples of mudstone and siltstone, from several stratigraphic levels of the Bullmoose Member, were submitted to J.H. Wall and D.J. McIntyre for microfossil and microfloral analysis respectively. Most samples yielded a prolific and diverse microfaunal assemblage (Appendix 2). The specimens identified by J.H. Wall include *Ammodiscus* sp. cf. *A. rotalarius* Loeblich and Tappan, *Bathysiphon* sp., *Hippocrepina* sp., *Miliammina* sp., *Haplophragmoides* sp., *Ammobaculites fragmentarius* Cushman, *Pseudobolivina* sp. cf. *P. rayi* (Tappan), *Gaudryina nanushukensis* Tappan, *Gaudryina tailleuri* Tappan, *Glomospirella* sp., *Lenticulina* sp., *Saracenaria valanginiana* Bartenstein and Brand, *S. projectura* Stelk and Wall, *S. Trollopei* Mellon and Wall, *S. dutroi* Tappan, *Marginulinopsis collinsi* Mellon and Wall, *Marginulina planiuscula* (Reuss), *Vaginulinopsis* spp., *Dentalina dettermani* Tappan, *D. praecommunis* Tappan, *D. strangulata* Reuss, *Pseudonodosaria* sp. cf. *P. kirschneri* (Tappan), *Conorbina* sp., *Serovaina loetterlei* (Tappan), *Quadrimorphina albertensis* Mellon and Wall, *Eurycheilostoma* sp. cf. *E. robinsonae* Tappan, and *Discorbis norrisi* Mellon and Wall. According to Wall the microfauna is characteristic of the *Marginulinopsis collinsi*–*Verneuilinoides cummingensis* Subzone of the *Gaudryina nanushukensis* Zone in the scheme of Caldwell et al. (1978), and is dated as late Early Albian. Diatoms, ostracodes and fragments of crinoids were also obtained from the samples.

Samples from Petro-Canada borehole 81-04 from the Monkman-Stony Lake area, collected by D.A. Leckie from strata herein included as part of the Bullmoose Member, yielded several Foraminifera specimens which include: *Ammodiscus* sp. cf. *A. crenulatus* Chamney, *Haplophragmoides* sp. *Quinqueloculina* sp., *Pseudobolivina* sp., *Nodosaria*? sp., *Lingulina* spp., *Globulina exserta* (Berthelin), and *Eoguttulina* sp. In addition, one specimen of the branchiopod *Cyzicus* sp. was recovered. These specimens, identified by Wall, were dated as Albian or Aptian.

In addition to the microfaunal assemblage, the dinoflagellates *Canningia* sp., *Chlamydophorella nyei* Cookson and Eisenack, *Cyclonephelium distinctum* Deflandre and Cookson, *Fromea amphora* Cookson and Eisenack, *Gonyaulacysta* sp., *Odontochitina operculata* (Wetzel) Deflandre and Cookson, and *Spinidinium* sp. cf. *S. vestitum* Brideaux were recovered from a sample collected near the base of the Bullmoose Member in the BP 53 borehole (Fig. 6). McIntyre suggests that the microflora is of Albian age.

Because the marine strata of the Bullmoose Member contain a microfauna that forms part of the late Early Albian *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi–Verneuilinoides cummingensis* Subzone, the strata correlate with the lower Moosebar Formation throughout the report area (see Appendix 2). Caldwell et al. (1978) recorded a similar microfauna from: the Clearwater Formation of the lower Athabasca River district of northeastern Alberta; the Wilrich, Falher and Notikewin members of the Spirit River Formation; partly equivalent upper Loon River Formation in the Plains area of the Peace River district of northwestern Alberta; the Luscar Formation of the Blairmore Group of central Alberta; and the Cummings Formation of the Mannville Group of the Alberta–Saskatchewan plains.

Sedimentary and biogenic structures

Sedimentary structures are common in the Bullmoose Member but are smaller in scale than those in the Gaylard and Chamberlain strata. They consist mainly of ripple lamination; wavy to lenticular to subparallel, dark grey, carbonaceous-argillaceous laminae; isolated ripple marks; and small- to micro-scale crossbedding (Figs. 43, 44). These primary structures are confined mainly to the rhythmically bedded, finer grained sandstones and siltstones. Locally, flaser bedding is common in the thicker bedded sandstones. Convolute or distorted laminae occur in the upper part of the finer grained sandy siltstones and mudstones of the fining-upward cycles. Rare syneresis cracks were observed near the top of the member near Sukunka River and in Bullmoose strata from the Petro-Canada DDH 81-04 borehole (D.A. Leckie, pers. comm., 1986). Most of the fine to coarse grained marker sandstones contain low-angle planar, and shallow-troughed festoon crossbeds.

Biogenic structures consist of vertical to subvertical to horizontal burrow traces of *Planolites, Skolithos* and other unidentified ichnogenera. Some *Skolithos* burrows are up to 1 cm in diameter by 13 cm in length. In addition, *Helminthopsis* and *Chondrites*-like traces were noted in some very fine grained sandstones and silty mudstones (Fig. 47). In core, the *Helminthopsis*-like traces resemble thin, dark grey mudstone rip-up clasts ranging from 2 to 5 mm in width and 1 to 2 mm in thickness (Fig. 47). Similar trace fossils occur in the overlying strata of the Chamberlain Member and Moosebar Formation. Biogenic mottling and bioturbation are common in the finer grained, darker grey, carbonaceous mudstones and shales. These commonly obliterate or destroy much of the laminated character of the sediment (see Figure 36).

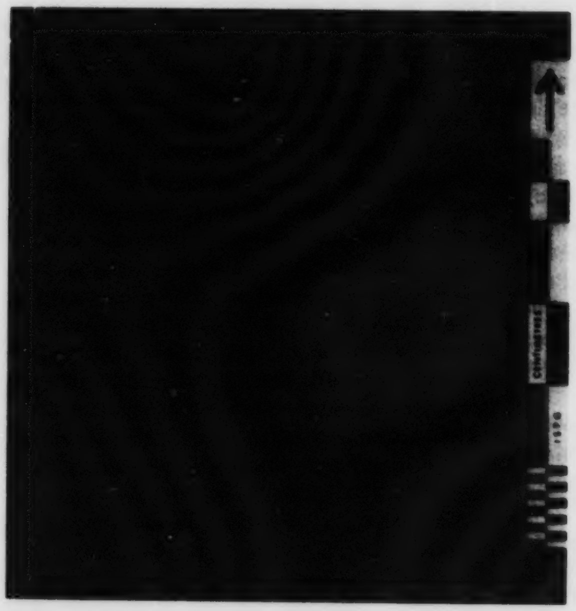


Figure 47. Chondrites sp. in mudstone and siltstone core of the Bullmoose Member from borehole BP 2. Note dark grey mudstone-filled Helminthopsis or Helminthoida-like burrow traces, and distinct fining-upward storm pulse deposits or tempestites. ISPG photo. 2473-9.

CHAMBERLAIN MEMBER

Definition, distribution and thickness

The Chamberlain Member occupies the stratigraphic interval between the sandstones, siltstones, mudstones and shales of the Bullmoose Member below and the siltstones, mudstones and shales of the Moosebar Formation of the Fort St. John Group above (Figs. 5-7, 10b, 12, 13, 15, 41, 42, 48). The strata are massive and generally cliff forming in outcrop, and consist predominantly of sandstone, conglomeratic sandstone and conglomerate with lesser amounts of siltstone, mudstone, shale, and coal.

Strata of the Chamberlain Member were first recognized and described as a distinct unit of the Gething Formation, by geologists of BP Canada Limited, in the Burnt–Sukunka rivers area of northeastern British Columbia. Wallis and Jordan (1974), in a paper on the stratigraphy and structure of the Gething Formation in the area of Sukunka River, informally divided the Gething Formation into two units, an upper Gething sequence and a lower Gething sequence. The contact between the two sequences was placed at the base of a thick coal seam, locally known as the Chamberlain Seam (Fig. 6). At the time of the investigation they did not recognize the significance of the Bullmoose marine strata within the Gething Formation. Subsequently, Duff and Gilchrist (1981) subdivided the Gething Formation into three units and designated the upper sequence as the Chamberlain member (Fig. 2). However, no description was provided and a type section was not assigned for the new member, so that it remained informal. Because of the potential economic importance and distinctive lithological character of these upper Gething strata in part of the report area, and the acceptance by industry and other workers of the name Chamberlain, the writer herein formally adopts the name Chamberlain Member to designate this unit as a separate and locally distinct marker facies of the Gething Formation in the Burnt-Sukunka rivers and Monkman-Stony Lake areas of northeastern British Columbia.

Several cored coal exploration boreholes and one field locality could serve as type or reference sections for the Chamberlain Member. However, because recognition and regional delineation of the member depend mainly upon the recognition of the underlying strata of the Bullmoose Member, it is suggested that the type section should be located where both major lithofacies successions are well developed and easily identified. Accordingly, borehole BP 53 in the Sukunka River-Bullmoose Mountain area (Figs. 1, 6, 7; UTM 588170E, 6120861N; topographic map of Sukunka River, NTS 93 P/4, 1:50 000 scale) is designated as the type section for the Chamberlain Member and a detailed description is provided in Appendix 3. The borehole is cored throughout. The member is thick, dominated by four, major, fine to coarse grained sandstones, and contains three economically important coal horizons (Chamberlain, Skeeter, and Bird seams; Figs. 6, 7). The name of the member is derived from Mount Chamberlain and Chamberlain Creek, two prominent geographic features in the area. The core may be examined at the core and sample storage facilities of the British Columbia Ministry of Energy, Mines and Petroleum Resources at Charlie Lake, British Columbia. The field section at Bullmoose Mountain (Section 80-1 in Figure 6) provides an alternative reference locality where outcrops typical of the Chamberlain Member can be readily examined. The Bullmoose section is illustrated in Figures 6, 10b, 15, 41, 42 and 48, has been described by Stott (1973, p. 220), and is included in Appendix 3. Access to the section has been described above.

Figure 48. Contact and lithological relationships between the Moosebar Formation and the Chamberlain Member of the Gething Formation at Bullmoose Mountain (Sec. 80-1). Note resistant, darker weathering, glauconitic, transgressive sandstone at base of Moosebar Formation. Cliff face above Moosebar consists of Gates Formation of the Ft. St. John Group. Moosebar Formation (Mb); Chamberlain Member (Ch). ISPG photo. 2065-16.

In the Monkman-Stony Lake area to the south, several coal exploration boreholes have penetrated a thick, sandstone, conglomerate and coal lithofacies forming the upper half of the Gething Formation. Because of the stratigraphic similarity to the Chamberlain facies in the north, combined with the occurrence of strata similar in character to the marine Bullmoose Member below, the succession is interpreted as a facies of, and equivalent to, the Chamberlain Member. However, because of slight differences in the lithostratigraphy of both the Chamberlain and Bullmoose members between the two areas, the possibility exists that the two Chamberlain facies may be only superficially similar, and the Chamberlain in the Monkman-Stony Lake area may represent a progradational tongue of the Gething Formation, developed stratigraphically below the level of the Chamberlain facies in the north. Additional work is required to resolve this problem.

In contrast to the northern area, the Chamberlain in the south is characterized not only by thick sandstones and coal seams, but also by thick units of conglomeratic sandstone and pebble conglomerate (Figs. 5, 49, 51). Facies typical of the Chamberlain Member may be examined in coal exploration boreholes Pacific 78-03 (Fig. 4; UTM 644485E, 6072158N; topographic map of Kinuseo Creek, NTS 93 I/15, 1:50 000 scale) and Pacific 78-08 (Fig. 4;

Figure 49. Conglomerate, conglomeratic sandstone, siltstone and mudstone of the Chamberlain Member, Monkman–Stony Lake area, in core from Petro-Canada DDH 81-04. Note fining-upward character of the conglomerate-sandstone, and sharp erosional base of the upper conglomeratic sandstone and conglomerate. Top of core (T). Bottom of core (B). ISPG photo. 2674-6.

UTM 644972E, 6070928N; topographic map of Kinuseo Creek, NTS 93 I/15, 1:50 000 scale). For additional cores and outcrop areas illustrating facies typical of the member, the reader is referred to the cross-sections in Figures 5 to 7, and 10b.

The Chamberlain Member has a limited regional distribution and closely parallels that outlined previously for the Bullmoose Member (Figs. 5-7, 10b, 12, 13). The member can be recognized in most areas of the Foothills between Burnt and Sukunka rivers in the north, and the Monkman–Stony Lake area to the south (Figs. 5-7). In the Foothills north of the Burnt–Sukunka rivers area, the Chamberlain abruptly grades laterally into thin bedded marine siltstone, mudstone and shale of the Moosebar Formation, a transition readily apparent north of Burnt River and in the vicinity and east of the Gwillim Lake and Murray River area (Figs. 6, 7, 10b). For example, in the Getty Gwillim C-27-E well (Fig. 7), the Chamberlain Member is thin and consists predominantly of fine to very fine grained sandstone with no obvious seams of coal. At the Phillips Puggins C-40-L well to the northeast (Fig. 7) the member can no longer be recognized, the sandstones having graded laterally into marine strata of the Moosebar Formation. As discussed above, the Chamberlain Member displays a similar lateral facies relationship with the Moosebar Formation in the Brazion and Hasler Creek area north of Burnt River. At the Gulf Goodrich 81-06 borehole (Fig. 7), the strata capping the cored interval represent a distal facies or tongue of the Chamberlain Member. However, because of the high concentration of interbedded siltstone and mudstone in the sandstone unit, the coal-free and plant-free character of the rocks, and relatively thin development of the lithofacies, the strata are best included as part of the Moosebar Formation.

Legun (1985a), described the northern and eastern limits of the Chamberlain facies in part of the Peace River Coalfield. In most areas of the Foothills south of the Monkman–Stony Lake area, strata of the Bullmoose Member can no longer be recognized with any degree of confidence. In this region, the Gething Formation is undifferentiated (Figs. 4, 5, 10b). However, the thick conglomerates and medium to coarse grained sandstones in the upper Gething Formation at Dumbgoat Mountain and Holtslander Creek (Fig. 4) may be equivalent to the Chamberlain Member in the north. The recognition and distribution of the Chamberlain Member, like the Bullmoose Member, in the Plains area to the east and southeast, is uncertain and remains speculative. Petroleum wells illustrated in Figure 5 are characterized by conspicuous, thick, sandstone and conglomerate units, with associated thick seams of coal in the upper third of the Gething Formation. These coarse clastic strata and coals are similar in composition and lithological character to those in the Chamberlain Member to the west and northwest. However, because of the difficulty in recognizing the Bullmoose Member in these wells, it is not known whether the strata form part of the Chamberlain Member or whether they should perhaps be included as a facies of the Bluesky Formation. Additional work is necesary to resolve the stratigraphic relationships among the Gething Formation, Chamberlain Member, and the Bluesky Formation of the Fort St. John Group in the subsurface area of the Plains.

The Chamberlain Member ranges in measured thickness from a maximum of 99.5 m at the type section (Figs. 1, 6, 7) to a minimum of 10 m at the Canadian Superior a-66-I well near the British Columbia–Alberta border (Fig. 6). These values suggest a marked thinning trend from the type area toward the east and southeast (Figs. 6, 7). In the Monkman–Stony Lake area to the south, the Chamberlain Member attains a maximum thickness of 72 m at the Pacific MDD 78-04 borehole (Fig. 5a). However, if the Bullmoose Member is limited to the interval shown at Five Cabin Creek (Fig. 5b) the Chamberlain Member may be up to 99 m thick. As in the area to the north, the Chamberlain facies thins toward the east and into the subsurface of the Plains.

Lithology

Strata of the Chamberlain Member comprise a massive, relatively thick succession of fine to coarse grained sandstone, conglomeratic sandstone and pebble conglomerate, interspersed with lesser, thin to thick units of finer grained sandstone, siltstone, mudstone, shale, and thin to thick seams of medium to low volatile bituminous coal (Figs. 5-7, 10b). The coarser grained strata form the predominant rock types of the member in most of the report area, particularly in the Foothills and western Plains. For example, at the type section near Sukunka River, the coarser grained sandstone comprises 82 per cent of the Chamberlain Member. In the Monkman–Stony Lake area to the south, sandstone and conglomerate comprise between 56 and 80 per cent of the total strata. Four distinct lithofacies and one lithofacies assemblage characterize the Chamberlain Member. They are: fine to coarse grained sandstone; conglomerate and conglomeratic sandstone; siltstone-mudstone; and rhythmic alternations of very fine grained sandstone, siltstone and mudstone. Coal is described below under a separate heading.

Fine to coarse grained sandstone

Fine to coarse grained sandstone forms the predominant rock type in the Chamberlain Member, occurring in units ranging from a few centimetres up to 30 m thick (Figs. 6, 50). The sandstone is moderately to well sorted and well indurated; in outcrop it forms massive cliffs and ledges along river and stream valleys or mountain ridges (Figs. 15, 41, 42). The sandstone is medium-dark to light grey, weathering orange-brown to brownish grey, depending on location and degree of exposure. Angular to subrounded grains of quartz, light and dark grey chert, and light grey limestone dominate the detrital components. Locally, carbonate grains and carbonate cement comprise the main mineralogical component of the sandstone, and the rock is a quartzose to cherty limestone. For example, for three of the thick sandstone units in borehole BP 2 (Fig. 6), thin section and X-ray diffraction analyses of samples revealed the following constituents: subangular to subrounded grains of quartz, medium to brownish grey chert, opaque to semi-opaque vegetal fragments, and well rounded to euhedral grains of limestone and dolostone, all cemented by recrystallized calcite and clay minerals. Rare grains of glauconite and plagioclase feldspar were also recorded. The mineralogy of the thin sections indicates a lithotype of very quartzose, cherty limestone. Other thin sections reveal well rounded to subrounded grains of quartz and chert, and rare clay minerals, cemented by silica and rare carbonate.

Many of the coarser grained sandstones exhibit a quartzitic texture and, where chert forms the predominant mineral component, the rock displays a conspicuous "salt and pepper" texture. Most of the thick sandstone units in the Sukunka River area lack conspicuous concentrations of plant or other organic components; however, some thick sandstones near or adjacent to coal seams, such as those in the Monkman–Stony Lake area, show an increase in the concentration of plant and other organic debris. Several of the sandstones contain vitreous coalspars (Fig. 51). In addition, sporadic, well rounded, "floating" pebbles of chert, quartz sandstone and orange-brown ironstone occur in some of the coarser grained sandstones. Furthermore, some of the sandstones contain dark grey to black, angular, siltstone-mudstone rip-up clasts, forming thin lenses of mudstone-chip conglomerate (Fig. 51). The angular clasts are generally oriented parallel to the bedding.

Figure 50. Fine to medium grained sandstone grading upward into darker grey sandy siltstone in the Chamberlain Member, Monkman–Stony Lake area, in core from Petro-Canada DDH 81-04. Note vertical sand-filled burrow near top and wispy, thin coalspars near base. Top of core (T). Bottom of core (B). ISPG photo. 2674–14.

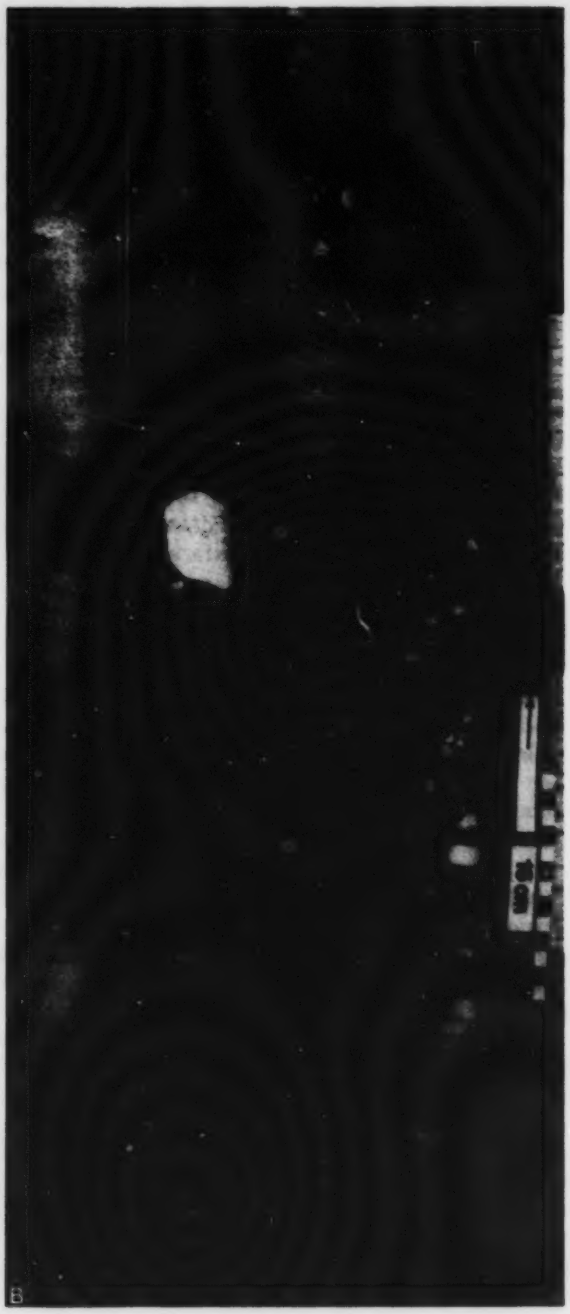


Figure 51. Interbedded conglomerate and fine to coarse grained sandstone of the Chamberlain Member, in core from Petro-Canada DDH 81-04. Note fining-upward character of the conglomerate; vitreous coalspars; and small, angular, dark grey mudstone rip-up clasts near base. Top of core (T). Bottom of core (B). ISPG photo. 2674–13.

In the Burnt–Sukunka rivers area, most sandstone units coarsen upward. However, at the type section (the BP 53 borehole), grain size trends within the thick sandstone facies are not obvious.

Conglomerate to conglomeratic sandstone

Conglomerate and conglomeratic sandstone in the Chamberlain Member were observed only in the Monkman–Stony Lake area to the south (Figs. 5, 10b, 49, 51). The conglomeratic facies occurs as thin to thick beds and/or lenses interspersed with beds of the fine to coarse grained sandstone described above. Compositionally, the strata are similar to those in the underlying Gaylard Member and Cadomin Formation. The conglomerate consists of well rounded, ovoid to elongate pebbles, cobbles and granules of green and light to dark grey chert; brown, spicular and phosphatic chert; buff, pink to white quartzite (forming the largest pebbles and cobbles); black to dark grey siliceous argillite; laminated dark grey to greenish grey siltstone; silicified dark grey limestone and dolostone (some of which contain abundant crinoid columnals); white quartzite with unusual, black, "hair-like" veins or fractures; and grey to buff, very calcareous to phosphatic, poorly indurated sandstone. The matrix of the conglomerate and conglomeratic sandstone is composed of fine to coarse grained quartz and chert sandstone, cemented by silica and calcite. Grains of green glauconite occur in some conglomerates adjacent to the overlying Moosebar Formation. In some samples, recrystallized calcite forms a conspicuously high concentration in the matrix and cement, perhaps infilling porous horizons subsequent to lithification. Much of the conglomerate is clast supported, particularly the thicker bedded units and lenses, although where it fines and grades upward or laterally into conglomeratic sandstone and sandstone, it is matrix supported (Figs. 49, 51). Pebbles are up to 12 cm in diameter with most ranging from 1 to 2 cm. Sorting is poor to moderate. Most of the clast supported conglomerate displays well developed stylolitic or pressure solution contacts between the component pebbles and cobbles.

Thin beds and lenses of dark grey mudstone-chip or edgewise conglomerate occur interspersed with the conglomerate at some localities. In addition, vitreous coalspars frequently occur in the coarser conglomerate horizons in the Monkman–Stony Lake area.

The conglomeratic sandstone consists of "floating" or matrix supported pebbles that range from 1 to 2 cm in diameter and which are compositionally similar to those in the main conglomerate facies. The host sandstone ranges from fine to coarse grained. Pebble and grain size trends are not conspicuous within this facies assemblage, although the pebbles are commonly smaller and the sandstone finer grained near the top.

Sandstone-siltstone-mudstone facies assemblage

This facies assemblage is not as conspicuous nor as thick as the similar facies found in the other two members of the Gething Formation. In the Chamberlain, the assemblage comprises a rhythmic succession of light and darker grey, very fine grained sandstone, siltstone, and mudstone to shale (Figs. 5-7, 10b, 52-54) commonly occurring between the thick units of sandstone and conglomerate. The sandstone at the base occurs as thin, wavy to lenticular beds, is medium to light grey, very fine grained, and commonly fines upward into darker grey siltstone, mudstone or shale. The assemblage is calcareous.

The thin, graded sandstones vary between 1 and 4 cm in thickness, although some beds range up to 22 cm. Some beds occur as isolated lenses surrounded by dark grey mudstone to siltstone.

Siltstone-mudstone

The siltstone-mudstone lithofacies is best developed adjacent to the thick coal seams, where it forms units ranging from a few centimetres up to 4 m thick. The rocks of this lithofacies commonly display a subconchoidal fracture and are characterized by a conspicuously high concentration of phytoclasts and vitreous coalspars. In addition, incipient, brown, ironstone mottling, bands and nodules may occur. Elsewhere in the member, where not part of the rhythmic facies, the siltstone-mudstone is more sandy and quartzose, although still calcareous, but does not contain carbonaceous plant matter (Fig. 49). Pyrite grains, crystals and thin laminae are locally common. Wavy to lenticular, light grey, sand and silt laminae characterize some of the dark grey mudstones. At three localities in the Monkman–Stony Lake area, the mudstone facies contains a conspicuous lighter grey, rooted to mottled mudstone, within carbonaceous, dark grey mudstone to siltstone. The lighter grey strata appear to have been leached and/or bleached during subaerial exposure (Figs. 55, 56). They have a superficial resemblance to bentonites, although they do not display the waxy or micaceous texture of bentonite. They may represent paleosols, a lithological type described in the section on the Gaylard Member.

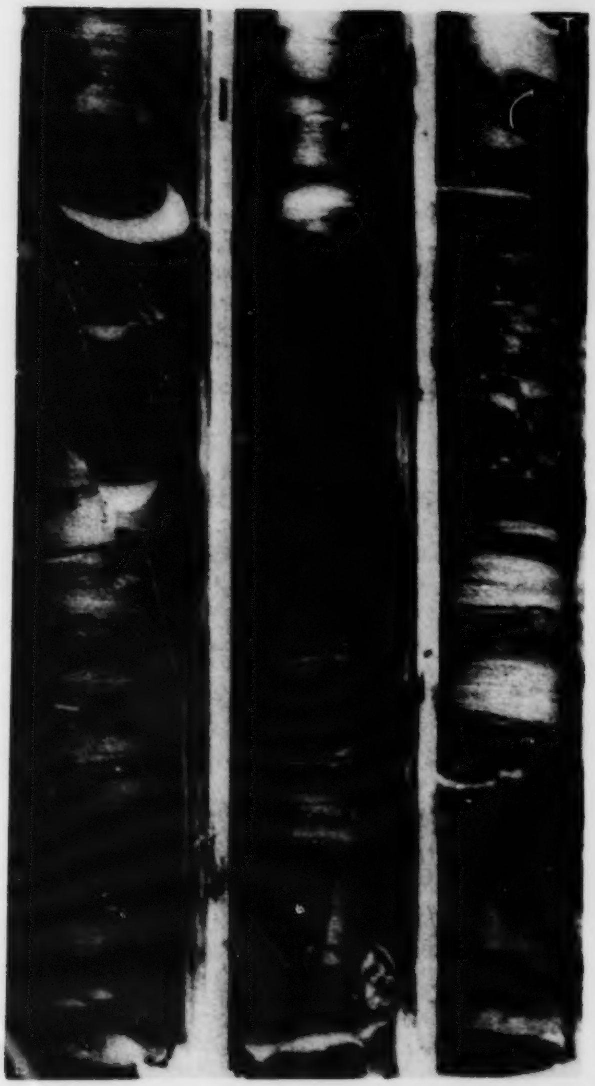


Figure 52. Rhythmic alternations of very fine grained sandstone to siltstone and dark weathering mudstone, in core from the Chamberlain Member at BP 53 coal exploration borehole. This facies occurs below the shoreface sandstone near top of member. Note sharp based, fining-upward character of sandstone couplets, and dark grey ***Helminthopsis****-like traces in lower right corner. Top of core (T). Bottom of core (B). ISPG photo. 2470–18.*

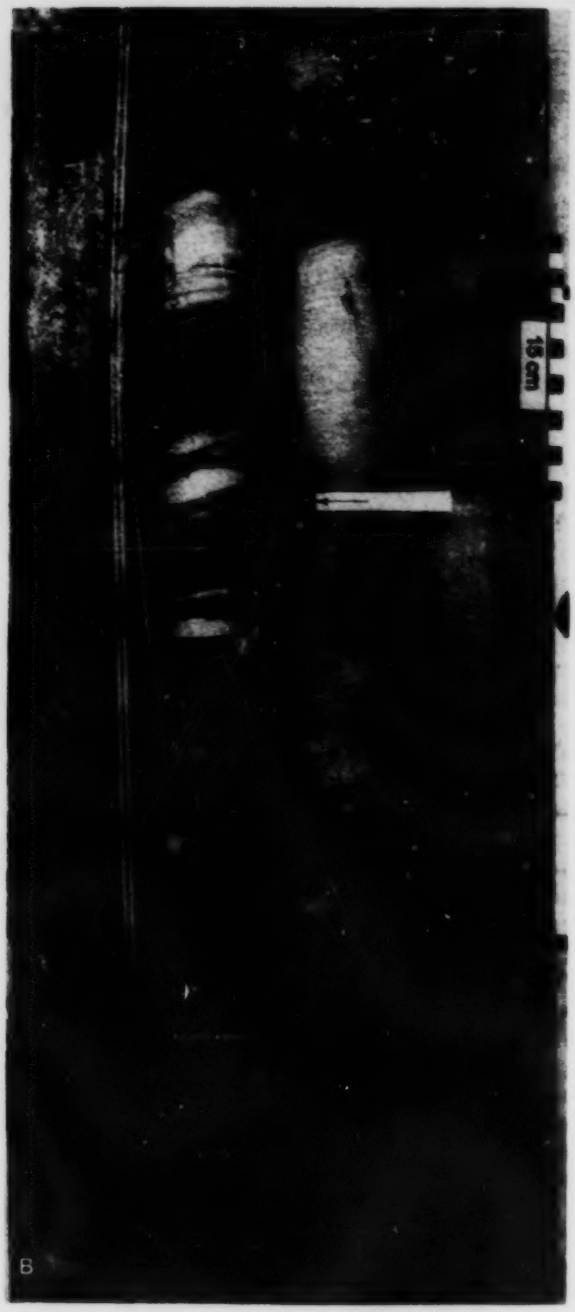


Figure 53. Wavy to lenticularly bedded, light grey sandstone in dark mudstone of the Chamberlain Member, Monkman–Stony Lake area, in core from Petro-Canada DDH 81-04. Note the coarsening-upward character of the lithofacies and distorted sandstone laminae. Top of core (T). Bottom of core (B). ISPG photo. 2674–18.

Figure 54. Close-up view of part of the core shown in Figure 53, illustrating syneresis crack (S), and distorted laminae in sandstone. Top of core (T). Bottom of core (B). ISPG photo. 2674–19.

Figure 55. Mottled mudstone to siltstone facies in the Chamberlain Member, the Monkman–Stony Lake area, in core from Petro-Canada DDH 81-04. Facies characterized in part by rootlets (R). Mottled facies near top may represent a paleosol (P). Top of core (T). Bottom of core (B). ISPG photo. 2674–16.

Figure 56. Close-up view of mottled paleosol-like mudstone-siltstone (P) and rootlets (R) shown in Figure 55. Top of core (T). Bottom of core (B). ISPG photo. 2674-17.

Facies variations

Facies of the Chamberlain Member display similarities and variations in development and lithology both parallel and normal to the structural fabric of the region (Figs. 5-7). The figures illustrate a conspicuous similarity between lithotypes along the structural strike in the Foothills. This similarity is best illustrated by the thick sandstone and conglomerate units that can be recognized as far south as the Monkman-Stony Lake area, and may perhaps extend to the area of Dumbgoat Mountain and Dokken Creek (Figs. 4, 10b). It must be noted, however, that in this southern area, the Bullmoose Member has not been recognized and may not be present. Accordingly, one cannot be certain that the thick sandstone and conglomerate facies at the top of the Gething Formation in this area is equivalent to the Chamberlain Member. One conspicuous regional facies variation is shown by grain or sediment size variations between the thick sandstones of the Burnt-Sukunka rivers area and their correlative facies in the Monkman-Stony Lake area to the south. Chert-pebble conglomerate and conglomeratic sandstone comprise a noteworthy component of the thick sandstone units in the Monkman-Stony Lake area, whereas they do not occur in the north. The most important regional facies variation occurs north of the Burnt-Sukunka rivers area, where the massive, thick, sandstone units and economically important coal seams grade laterally into thin bedded marine siltstones and mudstones of the Moosebar Formation (Figs. 7, 10b).

In addition to the regional variations, local changes also occur both parallel and normal to the structural strike in the area. Again, they are best illustrated by the occurrence and distribution of the thick sandstone and conglomerate facies within the member. For example, the 4.5 m thick sandstone overlying the upper Chamberlain Coal Seam at the type section (BP 53 borehole; Fig. 6) thins and grades laterally toward the southeast into an alternating succession of thin bedded, very fine grained sandstone, siltstone and mudstone (as shown at the BP 2 borehole; Fig. 6), over a distance of 8 km. Similar local facies changes can be seen in the Monkman-Stony Lake area (Fig. 5). In the Pacific 78-04 borehole, a prominent, 30 m thick, sandstone and conglomerate facies occurs above a thick coal seam located above the basal sandstone of the Chamberlain Member. However, in the adjacent Pacific MDD 78-08 borehole, the same sandstone and conglomerate facies has thinned to 14 m, whereas in the Pacific MDD 78-07 borehole to the west, the sandstone and conglomerate facies grades into a succession of interbedded, very fine grained sandstone, siltstone and mudstone and rare thin coals, with only one conspicuous sandstone unit, 2 m thick.

Contact relationships

The contact between the Chamberlain Member and overlying strata of the Moosebar Formation of the Fort St. John Group ranges from abrupt in most western Foothills areas to gradational and problematical in some eastern Foothills and western Plains areas, where the Chamberlain is overlain by strata of the Bluesky Formation (Fig. 6). At the type section near Sukunka River, the contact is abrupt and is placed at the base of a relatively thin, dark grey, fine to coarse grained to gritty, very argillaceous, very glauconitic, quartzose sandstone or sandy mudstone, which ranges in thickness from 0.10 to 1.85 m (see Figure 48). The sandstone is locally pyritiferous and conglomeratic, with "floating", well rounded, light and dark grey, quartz-sandstone and chert pebbles up to 5 mm in diameter. It is overlain by a thick succession of recessive mudstone, siltstone and very fine grained sandstone. The basal sandstone represents a thin, transgressive facies of the Moosebar Formation. In outcrop, the contact coincides with a conspicuous break in the weathering profile, between the massive, generally cliff-forming sandstones and conglomerates of the Chamberlain Member and the very recessive weathering, commonly talus covered mudstones and shales of the Moosebar Formation (Figs. 41, 42, 48). The uppermost Chamberlain Member generally consists of light grey quartzose sandstone with little to no glauconite, clay minerals or plant matter. However, at the BP 2 borehole (Fig. 6), the uppermost strata of the Chamberlain consist of coal (Bird Seam).

In most areas of the western Foothills, in the Monkman–Stony Lake area to the south, the contact is similarly abrupt, although at some localities it is slightly more difficult to assign. In this region, upper Chamberlain strata are characterized at most localities bv conglomerate and conglomeratic sandstone (Fig. 5), overlain by a generally thin, compositionally similar, conglomerate lag facies of the Moosebar Formation (see Figures 57, 58). However, the Moosebar conglomerate is darker grey, because of a greater concentration of argillaceous minerals and glauconite. The contact is placed at a level above which marine glauconite forms a conspicuous component of the conglomerate matrix. For example, in several of the Pacific MDD boreholes in the Monkman area (Fig. 5), the basal Moosebar conglomerate ranges in thickness from 0.2 m at the Pacific MDD 78-03 borehole to 1.38 m at Pacific MDD 77-3 borehole. Overlying the conglomerate facies at all localities are typical marine Moosebar strata (Fig. 57). The glauconitic conglomerate facies—not shown in all cross-section figures, is underlain by units, ranging from 5 to 21 m thick, of typical chert-pebble conglomerate and sandstone of the upper Chamberlain Member.

In the subsurface of the easternmost Foothills and most areas of the western Plains of northeastern

Figure 57. Moosebar Formation, showing basal transgressive conglomerate lag grading upward into dark grey mudstone to shale, core from Petro-Canada DDH 81-04. Top of core (T). Bottom of core (B). ISPG photo. 2674-5.

British Columbia, contact relationships between the Chamberlain Member and strata of the Fort St. John Group are problematical and locally uncertain. By tradition, many workers in the petroleum industry have included a relatively thin, but locally thick, sandstone facies, occurring between typical mudstones of the Moosebar Formation and coal-bearing strata of the Gething Formation, as a basal unit of the Fort St. John Group, naming it the Bluesky Formation (Alberta Study Group, 1954). As shown in Figures 5 and 6, many of the wells in the eastern Foothills and western Plains are characterized by one or more, thin to thick, conspicuous sandstone units, below typical mudstones of the Moosebar Formation (e.g., Pacific Ojay C-12-L, Canadian Superior Windsor a-66-I, and others). Because of the interdigitating nature of the Moosebar and Gething lithologies in the Foothills area to the west (Bullmoose and Chamberlain members), it is not certain whether only the uppermost or all of the thicker sandstone units should be included as part of the Bluesky Formation. Recent investigations by Smith et al. (1984) and Oppelt (1986) appear to include additional sandstone and mudstone facies occurring below the main or marker sandstone at the contact as part of the Bluesky Formation. Accordingly, it would appear that the Bluesky–Gething formational contact would be placed at a lower level, possibly coinciding with the base of the lowest major sandstone in the Chamberlain Member. In this investigation the contact between the Bluesky and the Gething Formation or Chamberlain Member is placed below the typical mudstone and siltstone facies and transgressive pebble lag of the Moosebar Formation (Figs. 5, 6). Because of the interfingering character of the Moosebar and Gething formations in the Foothills to the west (Fig. 12), combined with the complex and unresolved lithostratigraphic relationships between the Moosebar, Bluesky and Gething formations in the subsurface of the Plains area to the east, the most appropriate level at which to assign the upper Gething Formation, or Chamberlain Member, contact is still at the base of the easily recognized siltstones and mudstones of the Moosebar Formation. All thicker bedded sandstones, siltstones, mudstones or shales, including those strata with no coal, would thus be included as a distinct facies of the Gething Formation.

Figure 58. (Left) The contact between the Moosebar Formation (conglomerate) and the Chamberlain Member, in core from Petro-Canada DDH 81-04. Note abrupt erosional contact with uppermost coal seam of the Chamberlain Member and rooted (R) and ripple laminated character of sandstone and siltstone. The upward continuation of this core is shown in Figure 57. Moosebar Formation (Mb), Chamberlain Member (Ch). Top of core (T). Bottom of core (B). ISPG photo. 2674-4.

Age and correlation

The age of the Chamberlain Member is late Early Albian. The Chamberlain occurs between late Early Albian Bullmoose strata below and late Early Albian Moosebar strata above. No diagnostic fossils were obtained from the Chamberlain Member during the course of this investigation. Macrofossils are rare; only *Entolium irenense* and *Eupera onestae* were reported by Duff and Gilchrist (1981), and only indeterminate pectinid pelecypods were recovered by the writer. Like the same forms recovered from the Bullmoose Member below, they can be dated only as Cretaceous.

Several mudstone samples were submitted to J.H. Wall and D.J. McIntyre of the Geological Survey for microfaunal and microfloral analysis respectively. Most samples failed to yield any additional age information, although useful data were provided to assist in the interpretation of depositional environments. At the type section (the BP 53 borehole), the Foraminifera *Saccammina* sp., *Haplophragmoides* sp. A of Stelck and Wall, (1956), *Ammobaculites* sp., *Uvigerinammina*(?) sp., and *Conorbina* sp. B of Stelck and Wall (1956) were identified from the interbedded sandstone, mudstone and shale interval above the lowest major sandstone of the member. Wall suggests that the specimens are probably of late Early Albian age. The specimens were obtained from a thin marine facies equivalent to the underlying Bullmoose Member.

The dinoflagellates *Dingodinium cerviculum* Cookson and Eisenack, *Gardodinium trabeculosum* (Gocht) Alberti, *Muderongia asymmetrica* Brideaux, *Odontochitina operculata* (O. Wetzel) Deflandre, and *Palaeoperidinium cretaceum* Pocock and Davey, and the spore *Microreticulatisporites uniformis* Singh were identified from mudstone samples collected from near the base of the Chamberlain Member in the Pacific MDD 77-3 borehole (Fig. 5). The species, according to McIntyre, collectively suggest an Aptian to Middle Albian age. The foraminifer *Hippocrepina barksdalei* (Tappan) was also identified in the samples from the borehole.

Figure 59. Shallow-troughed, festoon and/or swaley crossbedding in shoreface sandstone of the Chamberlain Member at Bullmoose Mountain (Sec. 80-1). ISPG photo. 2065-15.

Because of the interfingering relationship between the Chamberlain Member and the Moosebar Formation and also because of the former's stratigraphic position between the Bullmoose Member and Moosebar Formation, Chamberlain strata are equivalent to the late Early Albian *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone. They are, therefore, correlative with the lower Moosebar Formation; part of the Buckinghorse Formation in northeastern British Columbia; the Clearwater Formation of the Athabasca River District of northeastern Alberta; the Spirit River and Loon River formations of the Peace River district of northwestern Alberta; the Luscar Formation of central Alberta; and the Cummings Formation of the Mannville Group in the Alberta-Saskatchewan Plains.

Sedimentary and biogenic structures

Primary sedimentary and biogenic structures in the Chamberlain Member are similar to those found in the Bullmoose and Gaylard members, although they are not as conspicuous nor as common. Medium- to large-scale, shallow-troughed, festoon crossbeds and parallel to low-angle, diverging, dark grey laminae occur in many of the thick sandstone units. The divergent laminae appear to represent foresets of medium- to large-scale, planar/tabular crossbeds. Most festoons display shallow troughs and occur interspersed with the low-angle, divergent laminae in the coarsening-upward sandstone units of the member. Some of the shallow troughs may represent swaley crossbeds that were not recognized during the investigation. Hummocky crossbeds characterize some of the finer grained sandstones that are interbedded with siltstone and shale near the base of the member. Small-scale festoon crossbeds, ripple and rare ripple drift bedding, and distorted laminae were noted in some of the thick sandstones and conglomeratic sandstones in the Monkman-Stony Lake area (Figs. 54, 60). Other thick sandstone units lack conspicuous sedimentary structures, except for faint parallel to wavy carbonaceous laminae and burrow structures (Fig. 61). The thin, wavy to lenticular bedded, finer grained sandstones and coarse siltstones display well developed ripple lamination (Figs. 52, 53). Stacked ripple lamination is common and some ripple laminated beds contain dark grey mudstone flasers. Microscale crosslamination and small load casts occur in some of the thin, coarser grained sandstone interbeds. Subaqueous syneresis cracks were observed in some of the dark grey mudstones in the Sukunka River and Monkman-Stony Lake area (Figs. 53, 54).

Figure 60. Small-scale festoon crossbedding, and parallel and ripple lamination in fine grained shoreface sandstone of the Chamberlain Member, Monkman-Stony Lake area, in core from Petro-Canada DDH 81-04. Note vertical and horizontal burrow traces (B). ISPG photo. 2674-23.

Biogenic structures or burrow traces occur in all facies of the Chamberlain Member (Figs. 52, 60, 62, 63). Many are similar in appearance to those in the underlying strata of the Bullmoose and Gaylard members although generally they are neither as common nor as well preserved. Two ichnogenera are

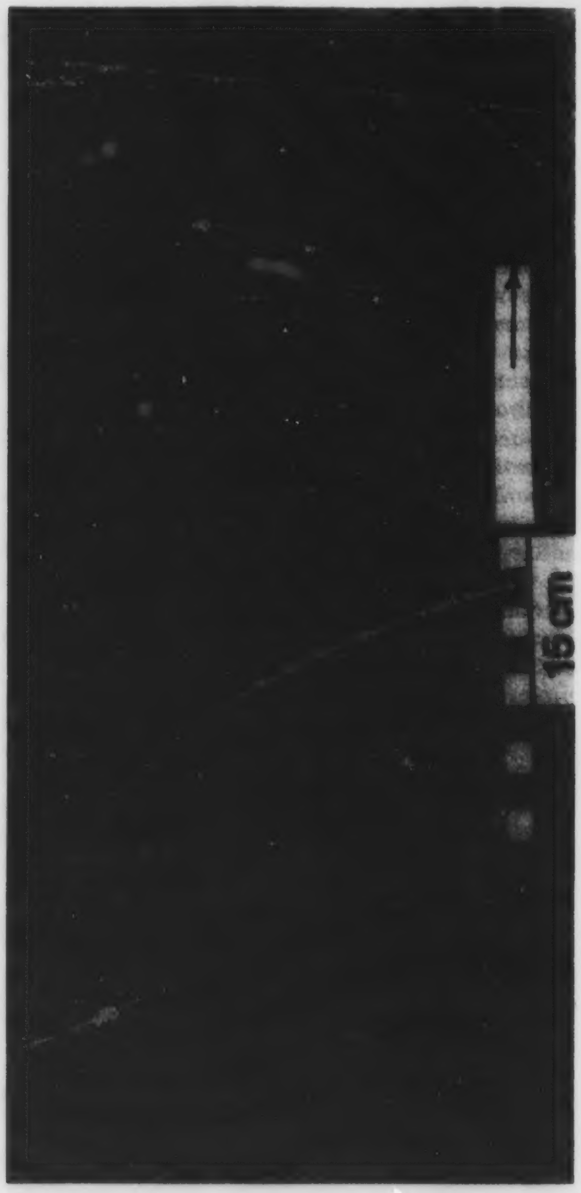


Figure 61. Fine, parallel to low-angle intersecting laminae in shoreface sandstone of the basal Chamberlain Member, Monkman-Stony Lake area, in core from Petro-Canada DDH 81-04. ISPG photo. 2674-25.

unique to the Chamberlain strata; well preserved *Paleophycus* and *Macaronichnus segregatis* traces (Figs. 62, 63) occur in some of the thick, fine to medium grained sandstone units in the Sukunka River and Bullmoose Mountain area. The *Paleophycus* burrows are horizontal to slightly inclined, sand filled, and display a prominent dark grey organic lining (Fig. 62). The burrow traces commonly range from 5 to 10 mm in diameter, with the length of most specimens exceeding the diameter of the core. At the type section, *Paleophycus* burrows were observed near the top of the basal sandstone of the member, in the next overlying thick sandstone, and in the first thick sandstone above the Chamberlain Coal Seam interval (Fig. 6). *Macaronichnus segregatis* burrows were associated with *Paleophycus* in some of the thick sandstones. These are similar in shape and orientation to *Paleophycus* but, in contrast, are more numerous and conspicuously smaller, ranging in diameter from 1 to 3 mm (Fig. 63). The *Macaronichnus* burrows were observed only in the uppermost part of the major thick sandstone units occurring below the Bird and Chamberlain seams in the BP 53 borehole. Other recognizable ichnogenera include *Planolites*, *Skolithos*, and possibly *Helminthopsis* and *Teichichnus*. These generally occur in the rhythmic, finer grained sandstones, siltstones and mudstones found between some of the major thick sandstones (Figs. 61, 64). With the exception of *Macaronichnus*, similar burrow traces were recorded in the finer grained sandstones and siltstones in the Monkman–Stony Lake area. However, in this region, they are not as common nor as conspicuous, a feature perhaps related to the depositional environment. Large *Planolites*-like burrows, 1 cm in diameter, were observed in the basal thick sandstone facies at the Pacific MDD 78-7 borehole (Fig. 5a).

Rhyzoliths or root structures similar in appearance to those in the Gaylard Member were observed in the upper few centimetres of some thick sandstone units in the Monkman–Stony Lake area (Fig. 58). Where the roots were well developed, the sandstones were directly overlain by coal or carbonaceous to coaly mudstones or shales. Wood moulds and casts were recorded in the uppermost cliff-forming sandstone at Bullmoose Mountain, and in a conglomerate and conglomeratic sandstone at the top of the Gething Formation at Dokken Creek (Fig. 5). Wood moulds and casts were

Figure 62. (Left) Paleophycos sp. burrows in shoreface sandstone of the upper Gething Chamberlain Member near Sukunka River. ISPG photo. 2473-1.

CENTIMETRES
ISPG

not observed in core, although some of the large coal-spars present in the conglomerates and coarse grained sandstones may represent coaly rinds of moulds and casts (Fig. 51).

OCCURRENCE AND DISTRIBUTION OF COAL IN THE GETHING FORMATION

Since the early investigations of Galloway (1913) and McLearn (1923) in the Peace River Canyon region of northeastern British Columbia, strata of the Gething Formation have been recognized as a potentially important source of coal. Subsequently, the occurrence, distribution and some analytical and petrographic properties of Gething coals have been described and discussed in varying detail by such workers as McLearn and Irish (1944), Mathews (1947), McLearn and Kindle (1950), Stott (1968, 1972a, 1973, 1974), Hacquebard and Donaldson (1974), Wallis and Jordan (1974), Karst (1979a, b), Gilchrist (1979), Duff and Gilchrist (1981), Kalkreuth (1982a, b; 1988), Kalkreuth and McMechan (1984, 1988), Legun (1984b, c; 1985a, b; 1986), Kilby (1984a, 1985), and Gibson (1985a). Most of these investigations have involved Gething coals in the areas of Sukunka, Pine and Peace rivers, and Carbon Creek. Currently, W. Kalkreuth of the Geological Survey of Canada is preparing a comprehensive report on the petrology of Gething coals.

The occurrence and distribution of coals in the Gething Formation in most of the important coal-bearing areas of northeastern British Columbia and west-central Alberta are illustrated in ten stratigraphic cross-sections (Figs. 3-10). The following discussion provides information on local and regional correlation of significant seams, areas or intervals of maximum seam development, and the rank of the coal where values are available. Unfortunately, most of the thick and potentially economic seams have been removed from the borehole cores by the coal exploration companies and, therefore, coal reflectance values are recorded mainly for samples collected from the thinner less economic seams—usually those less than 0.6 m in thickness. Two test localities were selected for coal sulphur analyses to determine if the

Figure 63. (Left) Macaronichnus sp. burrow traces in shoreface sandstone of the Chamberlain Member near Chamberlain Seam, in core from borehole BP 53. ISPG photo. 2473-2.

values could be used to assist in the interpretation of the depositional environment. Similar sulphur analyses proved useful in an earlier study of the Gething Formation in the Carbon Creek Basin (Gibson, 1985a). The coal occurrence and regional distribution information, when used in conjunction with the compositional and petrographic information provided by earlier workers, and more recently by Kalkreuth (1982a, b; 1988; in progress), should assist others in a better appreciation and assessment of the economic potential of the Gething Formation.

Gaylard Member

The occurrence and distribution of coal and important coal-bearing horizons in the Gaylard Member are illustrated in Figures 5 to 10. In comparison to other coals in the total Gething Formation, those in the Gaylard are relatively thin, although, locally, they may attain thicknesses of up to 18 m (Duff and Gilchrist, 1981). Quantitatively, most seams occur in the Sukunka, Burnt, Pine and Peace rivers areas where the Gething is thickest. For example, in the Carbon Creek Basin (Fig. 1), the Gaylard Member attains a thickness in excess of 1100 m, with over 100 seams of coal. However, only 10 to 14 of these seams appear to be of sufficient thickness to warrant economic exploitation (Gibson, 1985a).

Gaylard Member coals range in A.S.T.M. rank from high volatile A bituminous to semianthracite, with the latter ranks reported by Kalkreuth and McMechan (1984), for samples collected from wells located in the eastern, or outer, Foothills. Most coals from the western, or inner, Foothills range from medium to high volatile bituminous in rank. Kalkreuth and McMechan (op. cit.) demonstrated a significant coal rank or thermal maturation level decrease between coal samples taken from the eastern edge of the outer Foothills and the western edge of the inner Foothills. They attribute the maturation level change to a westward decrease in the duration and depth of burial of Gething strata, in response to the timing of Laramide deformation events. Recent work by Kalkreuth and McMechan (1988) has shown that, in the area of Pine River and most regions to the north, Gaylard coals increase in thermal maturation level from the outer Foothills and Plains to the inner Foothills and Front Ranges.

Regional correlation of seams within the Gaylard Member is difficult and generally not reliable. However, local correlation between closely spaced sections in some areas is possible, as I have demonstrated in the Carbon Creek Basin area (Gibson, 1985a). Recent work by Kilby (1984a, 1985), using tonstein clay markers, has demonstrated that one seam or coal-bearing interval in the Gaylard Member can be correlated regionally. Using the tonstein marker, Kilby established the correlation of the uppermost major seam of the Gaylard Member in the Sukunka River area, with the second major coal seam (Trojan Seam) below the basal Moosebar Formation contact in the area of Peace River Canyon. Regional and even local correlation of other Gaylard seams has generally proven difficult and highly speculative, because of the rapid lateral lithofacies changes, lack of other distinctive lithostratigraphic markers, such as tonsteins or bentonites but, most importantly, because of the absence of time sensitive fossil markers.

The occurrence and distribution of coal seams in the northernmost part of the study area are shown in Figure 10a. The cross-section encompasses the area between the Foothills at Pink Mountain and Halfway River, to the western Plains near the British Columbia–Alberta border. In the vicinity of Sikanni Chief River to the north, the Gething Formation thins and becomes increasingly more marine in character, with the result that coal seams are rare or absent (Stott, 1973). As can be seen in the cross-section, only the Arco Pacific Robertson b-71-k well, near Halfway River, contains seams of noteworthy thickness. In this well, three seams ranging from 1 to 3.2 m in thickness were penetrated in the middle of the formation. At Pink Mountain, along strike to the northwest, several thin seams ranging in thickness from 0.05 to 0.5 m were encountered and sampled for petrographic and chemical analyses. The coals at this locality ranged in mean maximum reflectance value from 1.05% to 1.21% Rmax, indicating an A.S.T.M. coal rank ranging from high volatile bituminous A to medium volatile bituminous (Kalkreuth, 1982a). Sulphur analyses undertaken on all coal samples from Pink Mountain yielded values ranging from 0.62 to 2.8 per cent. Stott (1973) reported a structurally thickened coal seam at the south end of Pink Mountain, south of the measured section locality. However, this seam could not be traced or correlated along strike into adjacent areas. In the Plains area to the east, coal is rare to absent in the Gething Formation, with only thin lenticles and coaly partings encountered in the petroleum wells. It must be noted, however, that in most petroleum exploration wells, geophysical logs are generally not of sufficient sensitivity to record the occurrence and thickness of some of the thinner seams.

Coal exploration (trenching) in the Graham River area north of Williston Lake (Fig. 1) encountered several seams within the Gething Formation; however, they do not appear to be of sufficient thickness or quality to warrant economic exploitation (Utah Mines Limited, pers. comm., 1982).

The occurrence and distribution of coal at outcrop, borehole, and well localities between the Peace River Canyon area and the Alberta–British Columbia border area to the east are illustrated in Figure 9. It was in the western part of this area that Gething investigations were initiated by early workers, and where the occurrence and distribution of coal seams and coal quality data were first documented by McLearn (1923). Because of their distinctive character in the Peace River Canyon area, most of the thick coal seams of the Gething Formation or Gaylard Member were assigned individual names by McLearn (op. cit.). Within the area shown on the cross-section, coal seams are common, particularly in the thicker section and borehole localities of the western Foothills. However, the number of seams decrease eastward although, in contrast to those in the west, the seams are noticeably thicker locally. In the thicker sections of the western localities most Gaylard seams range in thickness from between 0.5 to 1 m, although some seams up to 2.6 m thick were recorded near the mouth of Halfway River. In the Peace River Canyon area, several of the named marker coal seams range from 1 to 1.5 m in thickness (Stott, 1969).

Mean reflectance values range from 0.93% to 1.45% Rmax, indicating coal ranks of high volatile to medium volatile bituminous. Hacquebard and Donaldson (1974) demonstrated that coals from the Gething Formation display an increase in rank from the top to the bottom of the formation. However, Gibson (1985a), in a study of Gething coals from the Carbon Creek Basin, noted that the increase in rank with depth is erratic, with many values displaying no systematic vertical trend. There is, however, a generally higher average rank value for coals occurring in the lower third of the formation (Gibson, op. cit.). Average coal reflectance values determined for each borehole and field locality shown in the cross-section in Figure 9 indicate a general coal rank increase westward, from the eastern Plains to the Foothills, a trend that has recently been described and discussed by Kalkreuth and McMechan (1988). The westerly increase in coal rank contrasts sharply with coal rank trends in the region south of Pine River as discussed below.

In the Carbon Creek Basin, located immediately west of the position of the cross-section illustrated in Figure 9, in excess of 100 coal seams were recorded by the writer in a stratigraphic interval of approximately 1100 m (Gibson, 1985a). The seams range from a few centimetres up to 4.3 m in thickness. Sixty-one of the seams are greater than 0.3 m thick, while ten seams range from 0.9 m to 4.3 m. The top of the Gething Formation or Gaylard Member in the Carbon Creek Basin has never been observed or penetrated in any of the coal exploration boreholes, although the uppermost Gething strata in the area are considered to be almost complete. Recent mapping by Legun (1985b, 1986) in the Carbon Creek Basin and adjacent Mount Rochfort area to the west indicates the presence of a similar number of coal seams in the Mount Rochfort area. However, in the absence of distinct biological or stratigraphic markers, correlation of seams between the two areas is uncertain. Reflectance values in the Carbon Creek and Mount Rochfort areas (not illustrated in the cross-section) range from 0.81% to 1.35% Rmax, indicating coal ranks varying between high and medium volatile bituminous.

Most of the thicker seams shown in the cross-section display rapid lateral thickness variations; for example, the Trojan Seam. At Aylard Creek, for example, this seam attains a thickness of 1 m, whereas at the BRI Dowling No. 4 borehole locality, the Trojan splits into two thinner seams, the upper of which occurs 43 m below the basal Moosebar Formation contact (Fig. 9).

Similar thickness variations can be seen in the boreholes and wells east of Hudson Hope. In Denison boreholes PD 80-01 and HHD 80-01, coal seams are numerous, although none are in excess of 1 m in thickness. In the petroleum exploration wells included in the cross-section, the seams are quantitatively less numerous, but relatively thick in comparison to those in the coal exploration boreholes. For example, in the Westcoast Coplin et al., 6-21-84 well, ten seams were penetrated, each with a thickness over 1 m and, near the base of the Gaylard, one seam attained a thickness of 2.6 m.

Figures 7 and 8 illustrate the important western Foothills areas between Pine and Burnt rivers, where coals of the Gaylard Member have been assessed by several coal exploration companies in recent years. Several thick seams occur throughout the Gaylard succession, although most are concentrated in the upper half of the member. Individual seams range in thickness from a few millimetres to 3.6 m. The uppermost coal zone in the Gulf Goodrich 81-06 borehole attains a thickness of 19 m; however, the interval contains several thin, coaly, shale and mudstone partings. Reflectance values in the area illustrated by the cross-section range from 1.04% to

1.81% Rmax, indicating an A.S.T.M. rank ranging from high to low volatile bituminous. Medium volatile bituminous coals are dominant in the western area. Rmax reflectance values for those coals for which reflectance data are available indicate generally higher average values from boreholes located to the east. In contrast, as noted above, average rank values north of this area display increasing coal ranks from east to west.

As in other areas, correlation of most seams by cross-section analysis is uncertain.

In the petroleum exploration wells to the east (included in the two cross-sections), several thick seams were penetrated in Gaylard strata. For example, at the Getty Gwillim C-27-E well, up to ten seams, ranging in thickness from 1 to 2.9 m, were encountered. Correlation of seams in this eastern area with those at other localities to the west is not possible, because of the lack of distinctive lithofacies markers or because of the wide spacing between most outcrop and borehole localities. The conspicuous thick seams at the Getty Gwillim C-27-E well appear to thin and decrease toward the Phillips Puggins C-40-L and Amoco Home Sundown A-10-A wells to the northeast. However, at the two wells near Kiskatinaw River and the British Columbia–Alberta border area, the seams of the Gaylard Member increase both in number and in thickness.

In the Burnt and Sukunka rivers area, illustrated in Figure 6, up to five seams that may be of economic interest occur in the Gaylard Member. These seams range in thickness from 1 to 3.7 m with the thickest ("B" seam) occurring in the BP 53 borehole.

Reflectance values range from a minimum of 1.08% Rmax in the west to a maximum of 2.29% Rmax near Kiskatinaw River to the southeast, indicating coals of high volatile bituminous to semianthracite rank. The reflectance values illustrate a pronounced decrease in Rmax values from east to west. For example, at the Wainoco Mink C-94-B well, coal reflectance values range from 2.06% to 2.29% Rmax, with all coals in the well attaining an A.S.T.M. rank of semianthracite (W.D. Kalkreuth and D.F. Stott, pers. comm., 1986). To the west, at the Denison QWD 74-03 borehole, near Wolverine River, reflectance values are noticeably lower, ranging from 1.68% to 1.91% Rmax, resulting in all coals being classified as low volatile bituminous. Farther west at the BP 81-13 borehole, near Sukunka River, reflectance values range from a low of 1.08% Rmax to a high of 1.25% Rmax, with the coals at this locality classed mainly as medium volatile bituminous. A similar decrease in thermal maturation or rank level from east to west was documented by Kalkreuth and McMechan (1984) in the Foothills to the south. They found a similar westerly decreasing trend for all Lower Cretaceous coals between the latitudes of Smoky and Narraway Rivers and longitudes bounded by the axis of the Alberta Syncline on the east and the westernmost Rocky Mountain Foothills. Kalkreuth and McMechan (op. cit.) attributed the rank decrease to a westerly decrease in the duration and depth of burial of coal deposits beneath the Upper Cretaceous and Tertiary sediments.

The outcrop and borehole localities near Burnt and Sukunka rivers and Bullmoose Mountain illustrate the difficulty in recognizing and correlating coal seams. For example, at borehole BP 53, the thick marker seam near the top of the Gaylard Member ("B" Seam), appears to correlate with one or more of the seams in the uppermost coal-bearing interval of borehole BP 81-13 north of Sukunka River. Moreover, at this northern locality an additional three relatively thick seams (3.13, 2.65, and 1.8 m thick) are found, which do not occur in borehole BP 53. At borehole BP 2 to the southeast the "B" marker seam does not occur. The equivalent stratigraphic interval is occupied by only siltstone and mudstone with no coal. However, at the outcrop locality on Bullmoose Mountain, the first thin seam below the top of the Gaylard Member may be equivalent to the "B" marker seam in the BP 53 borehole.

The distribution of Gaylard seams includes localities of the western Plains. There, seams reach a maximum of 3.05 m thick, but are not as numerous as in Gaylard sections to the west.

Several seams from the BP 2 borehole were analysed for sulphur to assist in the interpretation of depositional environments (Gibson, 1985a). The values ranged from 0.51 to 0.63 per cent, indicating coals low in sulphur that were probably associated with a freshwater depositional environment during their growth and deposition. In contrast, some of the Chamberlain Member coals contain relatively high sulphur values.

The occurrence and distribution of Gaylard Member coals in the Monkman–Stony Lake area to the south are illustrated in Figure 5. Gaylard coals in this area are generally thin, although a few seams range from 0.5 m to 2.13 m in thickness. Coal reflectance values range from a minimum of 1.24% Rmax to a maximum of 1.60% Rmax, indicating coals of medium to low volatile bituminous rank; however, most coals are of medium volatile bituminous rank. Regional reflectance values indicate a decrease from east to west, similar to that noted elsewhere and illustrated in some other cross-sections. Correlation of seams in this area does not appear to be possible because of the lack of distinct lithological markers and the wide geographic spacing between outcrop and most borehole localities.

Bullmoose Member

Because Bullmoose Member sediments were deposited in a predominantly marine environment coal and/or coaly strata are generally not present, with the exception of the BP 2 borehole (Fig. 6). In this borehole, a 0.25 m thick coal seam has been included in the base of the Bullmoose succession. The coal has a reflectance value of 1.45% Rmax, indicating an A.S.T.M. rank of medium volatile bituminous coal. The sulphur content of the seam is 1.75 per cent, suggesting a possible marine to brackish depositional setting. At the BP 53 borehole to the northwest, equivalent strata above the upper sandstone of the Gaylard Member consist of calcareous, carbonaceous mudstone to shale with only rare vitreous coal lenticles. Elsewhere in the area occasional dark laminae of plant debris were noted in some of the strata near the top of the succession.

Chamberlain Member

The occurrence and vertical distribution of Chamberlain Member coal seams near Burnt and Sukunka rivers, Bullmoose Mountain, and areas southeast of Tumbler Ridge are shown in Figure 6. The Gething Formation has been extensively drilled and studied in recent years by several coal exploration companies in the area of Burnt and Sukunka rivers to assess its coal potential. Results of the investigations indicate that the best and potentially most economic seams occur in the Chamberlain Member. Three main coal-bearing intervals have been delineated. In descending order these are the Bird, Skeeter, and Chamberlain seams (Fig. 6). Along the line followed by the cross-section in Figure 6 they range in thickness from 0.91 to 3.4 m, although elsewhere in the area they attain thicknesses of up to 4 m (Duff and Gilchrist, 1981). The Chamberlain Member seams can readily be correlated, although toward the Gwillim Lake area coal does not occur in the Chamberlain, the facies having graded laterally into a marginal marine succession of siltstone, mudstone and sandstone (Getty Gwillim C-27-E, Fig. 7). Two of the major Chamberlain seams appear to extend southward into the Monkman–Stony Lake area, as shown in Figure 5.

The Bird, or uppermost, seam of the Chamberlain Member occurs at or slightly below the contact with the marine Moosebar Formation depending on geographic locality. It occurs throughout most of the Burnt–Sukunka rivers area, with the exception of Bullmoose Mountain, where the seam has been eroded and removed during the Moosebar transgression. Alternatively, the seam may not have been deposited at this locality. The Bird Seam attains a maximum thickness of 2.88 m at the BP 2 borehole, although elsewhere in the area it attains a reported thickness of up to 3 m. Coal reflectance analysis of the one sample available yielded a value of 1.36% Rmax and an A.S.T.M. rank of medium volatile bituminous. A sulphur analysis of the seam indicated a concentration of 3.03 per cent.

The Skeeter Seam, an upper split of the underlying Chamberlain Seam (Fig. 6), ranges in thickness from 0.39 to 2 m, although Duff and Gilchrist (1981) reported a thickness of up to 3.9 m in other areas. The sulphur concentration in the seam at the BP 2 borehole, is 0.55 per cent. Reflectance values for the Skeeter range from 1.41% to 1.27% Rmax, indicating a coal of medium volatile bituminous rank. The thickness of the Skeeter Seam in the area indicates that the seam thins toward the southeast and that it may eventually disappear, or alternatively, may merge with the main Chamberlain Seam.

The Chamberlain Seam, as plotted on the cross-section, has a maximum thickness of only 3.1 m (Fig. 6). However, boreholes drilled elsewhere in the area (not shown) indicate a thickness of up to 4 m. The seam is a medium volatile bituminous coal.

The correlation of seams from the outcrop belt with seams in the petroleum wells to the southeast is tenuous. The three upper seams in the KM-AEG Mast d-80-A well may be equivalent to the Bird and Skeeter interval of the Sukunka River and Bullmoose Mountain areas to the northwest. Alternatively, they may represent totally different seams developed in an area east of the thick sandstone facies and may occur in an interval equivalent to that between the Bird and Skeeter seams in the west. The lowest seam penetrated in the Chamberlain interval at the KM-AEG Mast d-80-A well, because of its stratigraphic position above the basal sandstone of the Chamberlain Member, may be correlative with the Chamberlain Seam in the west. All the seams in the Chamberlain Member thin toward the southeast, disappearing at the Canadian Superior Windsor a-66-I well near the British Columbia–Alberta border. Coal reflectance values obtained by Kalkreuth (pers. comm., 1986) from well samples in the area indicate a range from 1.57% to 1.69% Rmax, with an

A.S.T.M. rank of low volatile bituminous coal. The coal reflectance values decrease from east to west like those recorded from Gaylard strata in the Sukunka River–Bullmoose Mountain area.

The occurrence and vertical distribution of coal in the southern part of the report area, where strata of the Chamberlain Member can still be recognized as a separate facies of the Gething Formation, are shown in Figure 5a. In the Monkman–Stony Lake area, two major seams dominate the Chamberlain succession. They range in thickness from 0.32 to 4.65 m, although the thicker seams in some areas contain thin mudstone or shale partings. The coals display reflectance values ranging from 1.19% to 1.48% Rmax, indicating an A.S.T.M. rank of medium volatile bituminous. Stratigraphic relationships between the sections in the Sukunka River area to the north and those in the Monkman-Stony Lake area to the south, combined with two conspicuous, thick, coal-bearing intervals in the Chamberlain succession in the southern area, suggest a possible seam correlation between the two areas. For example, the thick coal and coaly shale interval above the basal sandstone of the Chamberlain Member in the Monkman–Stony Lake area appears equivalent to the main Chamberlain Seam in the north. The uppermost seam in the Monkman area, although occurring at a level up to 15 m below the Moosebar Formation contact, may correlate with the Bird Seam in the north. Alternatively, the seams may be unrelated and occur at different stratigraphic levels. Correlation of these seams with the field section at Five Cabin Creek to the west is again uncertain. The two conspicuous coal seams at Five Cabin Creek (Fig. 5b) that occur above the thick sandstone in the lower third of the measured section may be equivalent to the Skeeter and Bird seams of the Burnt–Sukunka rivers area.

Undifferentiated Gething Formation

The absence of, or inability to recognize, the Bullmoose Member in outcrop, boreholes, and wells south of the Monkman–Stony Lake area prevents subdivision of the Gething Formation into its three members. Accordingly, the discussion of the occurrence and distribution of coal in this region encompasses the total Gething Formation. Furthermore, south of Kakwa River, strata equivalent to the Gething Formation are called the Gladstone Formation of the Luscar Group (Fig. 2; Langenberg and McMechan, 1985).

The Gething Formation and equivalent Gladstone Formation in the southern part of the report area are relatively thin (Figs. 3, 4, 10b, 46, 64, 65). Seams of variable thickness occur throughout these formations, although seams are generally thicker in the lower halves of the formations, particularly in the western Foothills. The occurrence and distribution of seams between outcrops at Dokken Creek and the petroleum exploration well Pacific Ojay C-12-L to the northeast are illustrated in Figure 5a. Thick coal-bearing intervals are conspicuous near the base of the Gething,

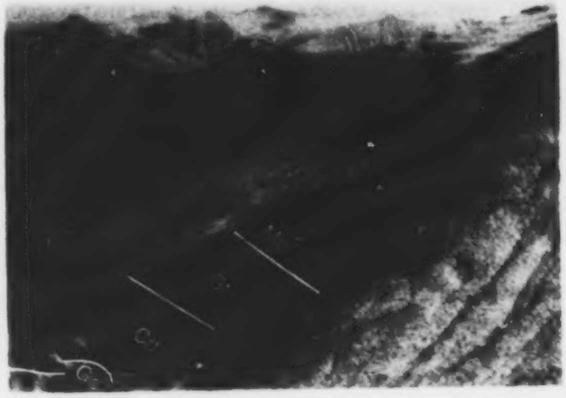


Figure 64. Contact and lithological relationships of the Cadomin, Gething and Moosebar formations at Mount Torrens (Sec. 82-4). The Moosebar Formation contains a thrust fault that repeats part of the section. Moosebar Formation (Mb); Gething Formation (Gt); Cadomin Formation (Cd); Gorman Creek Formation (Gc). ISPG photo. 2065-7.

Figure 65. Contact and lithological relationships between the Cadomin and Gladstone formations near Grande Cache, Alberta (Sec. 82-1). Cadomin Formation (Cd); Gladstone Formation (Gd). ISPG photo. 2649-9.

with seams ranging from 20 cm to 6.4 m thick. In roadside exposures near the headwaters of Triad Creek (Sec. 79-4, Denison adit, Fig. 5a), lower Gething strata contain two coal seams, 1 m and 4 m thick, respectively. Seams penetrated in the Pacific MDD 76-4 borehole are similar in thickness, and occur at about the same stratigraphic level as those to the northwest and therefore appear to be correlative. Elsewhere, the Gething contains several seams, with the most economically promising in the Pacific Ojay C-12-L well. There, seven coal seams were penetrated, varying in thickness from 1 to 3.2 m. At Dokken Creek, the Gething is characterized by many covered intervals that may be underlain by coal. Reflectance values for coals selected from undifferentiated Gething strata, vary from 0.88% to 1.35% Rmax, indicating ranks ranging from high volatile to medium volatile bituminous. The latter is the dominant coal rank in the area.

The occurrence and lateral distribution of coal seams in the Quintette Mountain and Wapiti Lake area are shown in Figure 5b. As discussed above, the region contains strata characteristic of all subdivisions of the Gething Formation. However, strata of the Bullmoose Member cannot be identified with any degree of confidence without detailed laboratory analyses. The strata are therefore grouped as part of the undifferentiated Gething Formation. Several seams, ranging in thickness from 1 to 3.5 m, occur in the upper part of the formation. These seams may correlate with the Bird Seam interval of the Sukunka River area and the uppermost seam in the Monkman-Stony Lake area to the west. In the lower third of the Gething Formation, up to six seams were penetrated in the wells. These seams range in thickness from 1 to 3.6 m.

In the Dumbgoat Mountain-Belcourt Creek area (Figs. 4, 16), coal seams are rare in the Gething, although up to three seams, ranging in thickness from 1 to 3.41 m, were encountered at the three outcrop localities illustrated in the cross-section (Fig. 4). Only two seams were noted at Dumbgoat Mountain. The three eastern localities shown on the cross-section contain two thick seams, near the base of the Gething, which may have economic potential. Regional reflectance values range from 0.96% to 1.46% Rmax, with the coals ranging from a dominance of medium volatile bituminous in the eastern subsurface to high volatile bituminous at outcrop localities in the west. As noted above, reflectance values display a marked decrease from east to west.

The cross-section in Figure 3 illustrates the distribution of coals in the southernmost Gething and equivalent Gladstone Formation between Narraway River and Grande Cache, Alberta. North of Kakwa River, several seams were encountered which range in thickness from 0.3 to 0.7 m. At the Petro-Canada MND 81-02 borehole, one seam near the top of the Gething Formation is 3.06 m thick. In the Smoky River-Grande Cache area to the southwest, coals in the equivalent Gladstone Formation display an erratic distribution and thickness. For example, in outcrop sections 82-1 (Fig. 65) and 82-2, on the east side of Smoky River, most seams in the Gladstone Formation are thin, ranging from 0.07 to 0.46 m. At Gustavs Flats (Sec. 82-7), on the west side of the river, the Gladstone, in contrast, is characterized by at least six relatively thick seams, one of which is 3.7 m thick and another 4.1 m thick. The two seams, however, cannot be recognized on the east side of Smoky River and thus appear to have a local and limited distribution. Coal reflectance values range from 0.81% to 1.85% Rmax, indicating coals ranging from high volatile bituminous in seams adjacent to Narraway River, to a predominance of low volatile bituminous coals in the remainder of the area to the southeast. Average reflectance values display a noticeable variation over relatively short distances between localities in the east and those in the west. For example, in the Petro-Canada MND 81-02 borehole, reflectance values range from 0.81% to 0.91% Rmax, while at Mount Torrens, 18 km to the east (Fig. 64), values range from 1.64% to 1.85% Rmax. It was in this southern region of the report area that Kalkreuth and McMechan (1984) demonstrated the pronounced westward decrease in rank of all Lower Cretaceous coals between the Alberta Syncline axis in the east and the westernmost Foothills of the Rocky Mountains to the west.

PALEOENVIRONMENTS AND HISTORY OF DEPOSITION

Introduction

Paleoenvironments and the history of deposition of the Gething Formation in northeastern British Columbia and west-central Alberta have been described and discussed in varying detail by McLearn (1923; 1931; 1932; 1944a, b), McLearn and Kindle (1950), Stott (1968, 1973, 1983, 1984), Wallis and Jordan (1974), Smith, Zorn and Sneider (1984), Jackson (1984), Legun (1983, 1984a, 1985a), Kilby (1984b, 1985), Kilby and Oppelt (1985), Oppelt (1986) and Gibson (1985a). Some of these reports are brief and lack supportive data, concern only specific geographic areas, or discuss only specific stratigraphic units or intervals of the Gething succession. The paleogeography of the Gething Formation throughout much of the report area, and other areas of the Interior Plains and Foothills of Alberta has been described and discussed in detail, in reports by Stott (op. cit.), Smith et al. (op. cit.), and Jackson (op. cit.). These reports provide illustrations outlining the geographic distribution of the coastal plain, deltaic, nonmarine and marine lithofacies of the Gething Formation. The paleogeographic interpretations of these authors suggest that much of the Gething Formation strata in the report area in northeastern British Columbia and west-central Alberta is of nonmarine or terrestrial origin. For example, Stott (1968, 1973, 1984) in his regional investigation of the Bullhead Group, indicated that the coal-bearing Gething Formation between Pine and Smoky rivers (Fig. 1) is of a nonmarine, alluvial plain origin. He demonstrated that the Gething strata became progressively more marine to brackish northward deposited in fluvial, deltaic, and marginal marine environments.

Smith et al. (1984) depicted the Gething Formation as a dominantly terrestrial succession of fine to medium grained sandstone, siltstone, mudstone and coal, which formed part of an interior drainage plain of low relief characterized by a series of northeasterly flowing rivers, which, in the vicinity of the western boundary of the Interior Plains, were deflected northwestward by a major fluvial trunk system known as the Spirit River Channel. Jackson (1984), in a companion paper outlining the paleogeography of the Mannville Group in Western Canada, likewise interpreted much of the Gething Formation strata in part of the report area as nonmarine in origin. However, in the vicinity of Sukunka River and other areas of the Alberta Plains, he indicated the presence of several areas underlain by marine siltstone and shale and some topographically high areas where Gething Formation strata were not deposited or preserved. The occurrence and distribution of the marine siltstones and shales outlined by Jackson (op. cit.) are interpreted by the writer as probable facies equivalents of the Moosebar Formation, deposited contemporaneously with strata of the Gething Formation in the Foothills to the west. Unfortunately, because of the difficulty in obtaining meaningful age information for subsurface Gething strata of the Plains, combined with the difficulty in obtaining useful age information from most of the surface or subsurface sections of the Gething deltaic/strandplain sediments in the report area, precise age and meaningful depositional environmental relationships between the Gething and Moosebar (or Moosebar equivalent) formations remain uncertain and speculative, particularly in the Plains area to the east.

The regional investigation by the writer and recent investigations by McLean and Wall (1981), Duff and Gilchrist (1981), Jerzykiewicz and Langenberg (1983), Legun (1983, 1984a, 1985a), Kilby (1984b, 1985), Kilby and Oppelt (1985), and Oppelt (1985, 1986) have shown that the Gething, and its southern equivalent the Gladstone Formation near Smoky River, contain marine and brackish water stratigraphic intervals that were not recognized by some of the earlier workers. This discovery provides additional evidence that the boreal Clearwater–Moosebar Sea transgression began earlier than previously suggested and appears to have extended to an area of the Foothills northwest and west of Calgary, and perhaps even as far south as Montana (McLean and Wall, op. cit.; Hopkins et al., 1982; Taylor and Walker, 1984; Burden, 1984).

In an earlier paper, the writer described the paleoenvironments and depositional history of the Gething succession in the Carbon Creek Basin (Gibson, 1985a). Preliminary stratigraphic and faunal evidence suggested that, at least locally in the Carbon Creek area, the Gething Formation formed part of a thick, deltaic, clastic wedge whose strata could be assigned to two major subenvironments of deposition. Strata of the lower half of the formation were interpreted as having been deposited in an upper delta plain depositional environment, whereas it was suggested that those in the upper half of the formation were typical of a lower delta plain depositional environment, one characterized by marine and brackish water inundations. Re-examination of the data, combined with the examination of additional coal exploration well cores and important new outcrop localities, now lead to the conclusion that most if not all of the Gaylard Member or lower Gething Formation sediments in the Carbon Creek area also were deposited in a lower delta plain depositional environment. Moreover, evidence presented herein suggests that almost the entire Gething Formation in other areas of northern British Columbia and west-central Alberta also may have been deposited in lower delta plain and shallow marine shelf depositional environments. Some southern areas, however, contain strata displaying characteristics of an upper delta plain (Bernard et al., 1973), or at least an environment in which strata were deposited under conditions that were less marine or brackish than those elsewhere in the report area.

The sedimentary facies, facies relationships and petrographic data, the presence or absence of diagnostic sedimentary and biogenic structures, and the occurrence or absence of characteristic megafossil, microfossil and microfloral assemblages, suggest that most strata of the Gething Formation were deposited in a deltaic coastal plain, or paralic, depositional environment. Strata of the Gaylard Member are interpreted as diagnostic of a lower delta plain environment, containing lithofacies comparable to Recent or Holocene fluvial and deltaic distributary channels, crevasse and overbank floodplain splays, flood basins, interdistributary bays and/or estuaries, and coastal plain swamps and/or marshes. Strata of the Bullmoose Member are interpreted as diagnostic of a marginal marine prodelta, or shallow shelf marine environment. Strata of the Chamberlain Member display features suggestive of deposition in a wave- or storm-dominated delta containing lithofacies that are interpreted as characteristic of shoreface, beach, distributary channel, estuary and/or lagoonal, and marsh or swamp depositional subenvironments.

Gaylard Member

Strata of the Gaylard Member, although interpreted regionally as representing facies of a lower delta plain depositional environment, have proven difficult to classify in terms of a specific delta model. Investigations by Galloway (1975), Coleman and Wright (1975), Elliott (1978), and Galloway and Hobday (1983), concerning modern delta complexes, have resulted in the recognition of different deltaic models. For example, Galloway (op. cit.) and Galloway and Hobday (op. cit.) classify most Holocene deltas into three main types: fluvial-dominated deltas, such as that of the Mississippi River; wave-dominated deltas, such as the São Francisco River of Brazil; and tide-dominated deltas, such as that of the Klang Langat River of Malaysia. Other investigators have proposed up to six models, although these delta types generally represent a combination of the three models of Galloway (op. cit.).

Throughout most of the report area the Gaylard Member is gradationally underlain by fluvial braidplain or alluvial fan strata of the Cadomin Formation. No obvious or suspected marine shelf or transitional marine beach/shoreface lithofacies have been recorded in strata of the Gaylard, although in the Pink Mountain and Halfway River area to the north, possible marginal marine sandstones characterize parts of the Gaylard succession. In the remainder of the report area, the Gething Formation and Gaylard Member appear to form part of a much larger deltaic or coastal plain clastic succession, which includes strata of the underlying Cadomin Formation of the Bullhead Group and perhaps most of the Minnes Group (for a description of Minnes Group formations, see Stott, 1970, 1981).

In the vicinity and north of Pine River, the first prominent marine to nonmarine deltaic lithofacies transition below the Gething and Cadomin formations is that which occurs between the Beattie Peaks, Monach and Bickford formations. The Beattie Peaks consists of mudstone and lesser siltstone and has been interpreted by Stott (op. cit.) as mid-basin, marine to prodelta in origin. The overlying fine grained to conglomeratic quartzose sandstones of the Monach Formation are interpreted by Stott as paralic delta-front to prodelta in origin. The overlying coal-bearing Bickford Formation is interpreted as marine to nonmarine.

South of the Pine River area, strata of the Beattie Peaks grade laterally and vertically into paralic strata of the Monach Formation which, combined with the overlying Bickford Formation, pass laterally into the mudstone, siltstone, sandstone and thin coals of the Gorman Creek Formation (Stott, 1981, p. 2). The Gorman Creek Formation is underlain by fine grained, argillaceous sandstone and mudstone of the Monteith Formation, which is interpreted as having a marine to nonmarine origin (Stott, op. cit.). It is suggested that within this southern area, at least to Smoky River, the marine Fernie, Monteith and Gorman Creek formations represent the first true marine to nonmarine paralic lithofacies transition below the Gething and Cadomin formations. The composition and deltaic character of these two Minnes Group transition facies compare favorably with that of a wave- or storm-dominated delta complex.

The absence of a paralic marine to nonmarine deltaic lithofacies transition at the base of the Gething and Cadomin formations may be explained by the occurrence of an unconformity, demonstrated by Stott (1968, 1973, 1983) and others, at the base of the Cadomin Formation in the Foothills and western Plains of the report area. The unconformity hiatus may represent an interval of time during which a marine to nonmarine transitional stratigraphic succession may have been deposited and subsequently removed from the area. However, in most western Foothills exposures and in many western coal exploration boreholes, evidence of a stratigraphic hiatus or unconformity is either lacking or not convincing. Sedimentation in the westernmost areas appears to have been continuous between the Minnes Group and Cadomin and Gething formations. Marine or marginal marine transitional lithofacies in this area, between the Cadomin and underlying Minnes Group, are not evident or have not as yet been recognized. Accordingly, the writer favours the interpretation of the much larger scale marine to nonmarine deltaic lithofacies transition, which includes strata in the

Cadomin and part or all of the Minnes Group, for the Gething succession.

Recent investigations by Leckie and Walker (1982), Leckie (1983, 1986; pers. comm., 1986) and Carmichael (1983), have provided evidence to suggest that most major marine to nonmarine Lower Cretaceous foredeep lithological transitions in the northern part of the Western Canada Sedimentary Basin formed part of wave- or storm-dominated deltas. The results of these investigations, when combined with the paralic, prodelta, and delta-front lithofacies interpretations of some formations in the Minnes Group (discussed above), suggest that the Gething Formation and Gaylard Member may likewise have formed within a similar wave- or storm-dominated deltaic succession. However, with the exception of those transitions in the Pink Mountain and Halfway River area to the north, conspicuous paralic shoreline lithofacies or lithofacies transitions are lacking at the base of the Gaylard Member and lower Gething Formation. The stratigraphic succession resembles one that is characteristic of fluvial- or tide-dominated deltas. Accordingly, the type of deltaic model, and the character and stratigraphic location of the marine to nonmarine transition lithofacies expected for the Gaylard Member and lower Gething Formation, remain to be resolved. It would appear that deposition of Gaylard and lower Gething strata was part of a complex environmental relationship in which sediment supply, regional and local subsidence, and changes in sea level were such that they allowed the deposition, accumulation, and slow progradation of a relatively thick fluvial-deltaic stratigraphic succession. Available evidence (discussed below) seems to suggest that during most of Gaylard time the boreal Clearwater-Moosebar Sea was not far removed from the subenvironments of the north to northeasterly-advancing clastic wedge.

Following deposition of the braidplain and/or alluvial fan sediments of the underlying Cadomin Formation (Stott, 1973; McLean, 1976, 1977; Rust, 1979), much of the report area was again subjected to the influence of the southerly transgressing boreal Clearwater-Moosebar Sea. Effects of the marine transgression were first recognized in Gething strata of the Carbon Creek Basin and Peace River areas, and adjacent areas to the north and south. Evidence of the transgression and consequent marine influence on deposition of Gaylard strata in the area includes: the occurrence of marine to brackish water bivalves in strata of the Carbon Creek Basin (Gibson, 1985a); the occurrence of marine foraminifers in the area of Mount Rochfort west of the Carbon Creek Basin (Appendix 2); the occurrence of restricted marine foraminifers from lower strata of the Gaylard Member near Bennett Dam (Chamney, 1973); extensive bioturbation and a profusion of marine-like trace fossils including *Planolites*, *Skolithos*, and *Teichichnus* (Howard and Frey, 1984) throughout the Gaylard succession; and the occurrence of subaqueous syneresis cracks (Donovan and Foster, 1972) in many mudstones and siltstones of the Gething succession. Several coal seams in this northern area contain sulphur concentrations in excess of one per cent, a property generally indicative of deposition adjacent to a marine environment (Stach et al., 1982). Lastly, in the Pink Mountain and Halfway River area to the north, clean, well indurated, fine grained, quartz sandstones, lacking plant or other conspicuous vegetal components, may be indicative of strong storm wave agitation in a marine to brackish marine environment. These sandstones do not display textures or sedimentary structures typical of fluvial channel or other associated delta plain depositional subenvironments.

In the Burnt-Sukunka rivers area to the south, and perhaps other areas farther south near Stony Lake and Redwillow River, bioturbation, well developed burrows, occasional subaqueous syneresis cracks, and the occurrence of marine foraminifers in uppermost Gaylard strata in the Sukunka River-Bullmoose Mountain area, collectively suggest that part of the succession in this area was also deposited adjacent to or under the influence of a marine or brackish marine environment. However, the biogenic structures in the southern area are not as numerous or as conspicuous as those found in regions to the north. At the Pacific MDD 77-3 borehole near Stony Lake (Fig. 5a), foraminifers of probable marginal marine to brackish water origin were recovered from near the base of the Gaylard Member (Appendix 2). In the Grande Cache-Smoky River area, the southern limit of the investigation, the marine influence of the boreal sea transgression is not readily apparent in the stratigraphically equivalent lower facies of the Gladstone Formation. Lower strata of the Gladstone Formation contain only rare horizontal and vertical burrows which might suggest a possible brackish water influence in the environment of deposition. In contrast, however, strata of the upper Gladstone Formation have yielded marine bivalves (*Protocardium* sp.) and burrow traces (*Diplocraterion* sp.), indicative of a brackish or marginal marine depositional environment (Jerzykiewicz and Langenberg, 1983).

In addition to coal, fine to coarse grained sandstone, conglomeratic sandstone, and pebble conglomerate form the most conspicuous lithofacies of the Gaylard Member and lower Gething Formation. Their geometry, internal structure and sequence relationships suggest that many of the coarser grained clastic facies may be interpreted as lower delta plain distributary channel deposits. In outcrop, they form relatively thick ledges with a prominent lenticular profile, grading laterally into finer grained sandstones, siltstones, mudstones or shales (Figs. 19, 29). In both core and outcrop, they occur in units up to 14 m thick, erosionally overlying finer grained strata of probable floodplain or flood basin origin. Most of the channel sandstones illustrated in Figures 3 to 10 fine upward, although some coarsen upward or display no obvious grading at all. In outcrop, medium- to large-scale festoon crossbeds form a noteworthy component of many thicker channel facies, although, locally, planar/tabular crossbeds may also occur (Fig. 29). In core, the type of crossbedding is often difficult to determine, although most appears to be festoon. As in most channel facies the size or scale of the crossbeds decreases upward, in response to the decrease in velocity of the transporting river or stream. However, near Bennett Dam, the thick channel sandstones near the base of the Gaylard Member display unusual, large-scale, deformed cross-stratification and overturned cross-stratification which are interpreted as indicating possible compaction and de-watering of the sandstone, and strong current or fluid shear activity by the river currents (Fig. 30). Alternatively, the deformed cross-stratification may be due in part to soft-sediment slumping on a slightly inclined depositional slope. This unusual type of crossbedding has not been observed elsewhere in the Gething succession. In the area of Bennett Dam, well developed medium- to large-scale, epsilon crossbedding occurs near the base of the formation; again suggesting a fluvial, meandering channel origin for most thick sandstone facies in the Gaylard Member (Fig. 27). In addition, many of the channel sandstones contain well preserved ripple and cross-ripple lamination near the top of the facies (Fig. 31). Most channel sandstones grade upward into ripple laminated siltstone to very fine grained sandstone, and thin, parallel to wavy, ripple laminated mudstones; facies that may be of probable levee or overbank floodplain origin.

Some channel facies contain conspicuous lenticular beds or pockets of chert-pebble conglomerate and, less commonly, angular, dark grey clasts of siltstone and mudstone near their bases. In some thick channel facies, "pebble and angular clast" horizons occur as lenticular concentrations at several levels, probably related to the presence of channel reactivation surfaces. The pebbles and angular clasts, some of which are up to 4 cm in diameter, probably represent channel "lags", a facies characteristic of the base of many fluvial channel sandstone deposits (Reineck and Singh, 1973). In addition to the "lag" facies, many of the channel sandstones contain vitreous coalspars, some of which are up to 4.5 cm in diameter, and which represent coalified former tree branch, trunk or similar arboreal components (Fig. 18). They most commonly occur associated with the "pebble and angular clast" units, or, less commonly, they are randomly distributed within the channel facies. In outcrop, variable-sized wood moulds and casts occur near or at the base of some of the channel facies. They probably represent waterlogged, channel debris.

At some localities, thick units of pebble conglomerate, conglomeratic sandstone and coarse grained sandstone occur near the base of the Gaylard Member and undifferentiated Gething Formation (Figs. 4-6, 16). The conglomerate is moderately to poorly sorted and locally displays medium- to large-scale crossbeds, wood moulds, and casts. It generally grades upward into conglomeratic to coarse grained sandstone, although in some units conspicuous size trends were not apparent. Pebble imbrication was not observed. Most conglomerate facies were gradationally overlain by finer grained sandstones displaying small-scale crossbeds and ripple lamination, or by ripple laminated siltstones or silty mudstones. Because of their proximity to the massive, cliff-forming conglomerates and sandstones of the underlying Cadomin Formation, the Gaylard Member conglomerates are interpreted as representing tongues of the underlying Cadomin Formation (Figs. 12, 13). Accordingly, they represent probable channel bars within a distal braidplain or alluvial fan depositional environment.

Some of the fine to coarse grained sandstones and conglomeratic units in the Gaylard have proven difficult to interpret, because they display stratigraphic relationships and sedimentary structures that are common to more than one deltaic depositional subenvironment. For example, in the Carbon Creek Basin, the upper part of the Gaylard Member is characterized by a locally thick sandstone-conglomerate unit (up to 47 m thick), which may represent a major lower delta plain distributary channel (Gibson, 1985a, Fig. 4). Immediately below and above the facies are coal seams containing relatively high concentrations of sulphur, and highly burrowed and bioturbated mudstone and siltstone. These features in the adjacent strata would suggest that the sandstone-conglomerate unit was deposited adjacent to a marine to brackish water depositional environment, probably close to sea level or near the mouth of the channel. However, the occurrence of thin to thick beds and lenses of chert-pebble conglomerate so high in the Gething Formation above the Cadomin

Formation, is difficult to equate with deposits of a distributary channel of the lower deltaic plain adjacent to a marine or brackish water environment. Alternatively, the sandstone-conglomerate unit may represent an interdistributary bay or estuary beach, and have been introduced by a major distributary channel and then redistributed along the margin of the bay by wave action and longshore currents. Crossbedding is not common, and low-angle lamination, typical of modern beach facies, was not observed. Climbing ripples and burrows are rare, although *Skolithos*-like burrows, up to 2.5 cm in diameter, were noted. If the sandstone-conglomerate unit is part of a restricted interdistributary bay or estuary beach deposit, it developed on a mudstone-siltstone facies of a brackish water bay during part of a minor transgression. Subsequently, the sandstone-conglomerate unit was onlapped by more of the fine grained strata of the bay.

In the Halfway River and Pink Mountain area (Fig. 1), Gething strata are characterized by another noteworthy, fine to medium grained, channel-like sandstone lithofacies (Fig. 10). However, the sandstones are clean and quartzose with little obvious organic or vegetal plant matter, and form units up to 9.5 m thick. The sandstone is lighter grey than those in the southern parts of the report area, is well sorted, very siliceous and well indurated, and is found mainly in the lower half of the formation. It displays occasional planar/tabular crossbeds and well developed ripple lamination. Well preserved, *Skolithos*-like burrows were observed in a few samples. Based on the presence of burrows, the clean and siliceous nature of the sandstone, and their association with coals with a relatively high sulphur content, these sandstones may represent subaqueous distributary channel facies or distributary mouth bars, each developed in a standing body of brackish to marine water, such as a bay or large estuary. In the same area, two thick quartz sandstone units (up to 24 m thick), occur near the top of the Arco Pacific Robertson b-71-K well (Fig. 10), and likewise may represent a subaqueous distributary channel or distributary mouth bar, separated by a thin mudstone of possible brackish water to marine origin. Core is not available for the study of diagnostic sedimentary structures. These and other similar sandstone units in the northern part of the report area grade laterally or interfinger with bioturbated and burrowed siltstones and mudstones of probable brackish to marginal marine, interdistributary bay or estuary origin. These sandstones are generally characterized by gradational lower contacts, which contrast with the erosional contacts commonly found at the base of major, lower delta plain, distributary channels. Sedimentary relationships in this area are similar to those of the Carboniferous distributary mouth bar sandstones of Kentucky and West Virginia described by Horne and Ferm (1976).

Another noteworthy fine to coarse grained sandstone facies occurs at the top of the Gaylard Member in the Sukunka River–Bullmoose Mountain area (Figs. 5, 6). The sandstone caps a coarsening-upward succession of interbedded mudstone, siltstone and very fine grained sandstone, which at two localities contains marine foraminifers, burrow traces, bioturbation mottling, and occasional syneresis cracks (Fig. 15). The capping sandstone is quartzose, predominantly fine grained and contains small-scale crossbeds and ripple laminae, and, at two localities, *Skolithos*-like burrows up to 5 mm in diameter. The underlying finer grained facies was deposited in a marine to brackish water interdistributary bay or fluvial estuary with an open connection to the sea. The coarser grained sandstone capping the succession represents a geographically restricted facies of a beach or shoreface, deposited along the seaward margin of the bay environment. At the BP 2 borehole locality (Fig. 6), the top of the sandstone contains vertical rootlets and is overlain by a thin seam of coal, indicating that, at least in this area, a local swamp or marsh developed above or behind the beach.

In the Monkman–Stony Lake area in the south also, sandstone caps the Gaylard succession (Fig. 5). However, in much of the area, it displays sedimentary characteristics more typical of a large distributary channel with small- to medium-scale festoon crossbeds, an abundance of fragmented plant debris, coalspars and channel "lag" pebbles. The sandstone is medium to coarse grained, and at most localities is characterized by an abrupt erosional base. However, at the Pacific MDD 79-18 borehole, the geometry and internal structure of the sandstone differs. Here, the contact with underlying strata is gradational, and the strata are bioturbated and contain pyritiferous laminae typical of a marine to brackish water interdistributary bay environment. The capping sandstone is quartzose and clean, with no conspicuous plant matter, and displays diverging, low-angle laminae, similar in character to those of a wave-worked beach or shoreface environment. At some localities the sandstone is overlain by a thin, transgressive, pebble "lag", which in turn is overlain by storm-generated, fining-upward, thin, sandstone, siltstone and mudstone beds, with abundant burrow traces. The pebble "lag" and overlying beds are included as part of the Bullmoose Member.

In addition to the relatively thick distributary channel sandstones, Gaylard and lower Gething strata in the southern part of the report area also contain many thinner sandstone units of crevasse splay and overbank and/or levee origin (Figs. 19, 20). These sandstones, a subfacies of the floodplain environment, were deposited in the interfluvial or interdistributary channel areas of the lower delta plain. Some of the facies may represent parts of small interdistributary bay or lacustrine deltas.

Sandstones of crevasse splay origin contain many compositional and textural features and sedimentary structures similar to those found in sandstones of the major distributary channels. However, several differences may be apparent. For example, crevasse splay sandstones are generally finer grained and non-conglomeratic, and commonly contain a greater concentration of carbonaceous, argillaceous and vegetal particulate matter, resulting in a darker colour. In addition, crevasse channels form thinner and laterally more restricted units than those of major distributaries. Crevasse sandstones typically become finer grained and thinner bedded away from the major channels and, if they empty into lacustrine or marginal marine bay or lagoonal environments, may form small coarsening-upward deltaic sequences (Fig. 23). Most splay sandstones are characterized by small-scale festoon crossbedding near their bases, grading upward into ripple drift crossbedding and ripple and contorted or distorted lamination. Parallel lamination and, locally, scour and fill structures also may occur. Many of the channel splays of the Gaylard Member fine upward, grading into very fine grained sandstone, siltstone and/or mudstone with, in some localities, thin to thick seams of coal. Crevasse splay sandstones also may possess sedimentary properties that are similar to those of subaerial levee deposits, and, as noted by Reineck and Singh (1973) and Ethridge et al. (1981), the two depositional types may be difficult to distinguish. Levee facies, although not positively identified in the Gaylard succession, should display some evidence of subaerial exposure such as mudcracks, burrow structures, rootlets, or root bioturbation.

The interbedded finer grained sandstone, siltstone and mudstone or shale form a conspicuous and common facies assemblage of the lower Gething Formation and Gaylard Member (Figs. 19, 20, 29). The assemblage mainly represents overbank flood basin and distal splay environments. Some of the thicker but finer grained units may represent facies of interdistributary bay deltas or estuaries and freshwater lakes, swamps and marshes. These interfluvial or interdistributary channel facies comprise a major component of most deltaic successions. The fine to very fine grained sandstones contain well developed ripple and rare microscale crossbedding (Fig. 31). Contorted or distorted laminae may be common. Burrow traces and bioturbation mottling are conspicuous in the thinner bedded sandstones north of the Pine River area, suggesting sediment deposition in a brackish water to marine environment (Fig. 36). Where mudstones occur as conspicuous facies devoid of coarser grained, siltstone and sandstone interbeds, they represent suspension or vertical accretion lacustrine deposits (Figs. 5-10). However, if the mudstones display burrows and bioturbation mottling, they are more likely to have been deposited in a marine or brackish water environment, such as an interdistributary bay or, possibly, an estuary. Where vegetal matter or phytoclasts form a conspicuous concentration or actual accumulations to produce thin lenses and beds of coal within the siltstone and mudstone facies, such strata may represent the vegetated margin of a delta plain lake or part of a flood basin marsh or swamp. In the latter case, the carbonaceous or coaly mudstone may grade laterally and vertically into thin to thick seams of coal; whereas, in the former case, the mudstone or shale facies may grade into plant-free claystones, siltstones or mudstones more typical of a lacustrine environment. As noted previously, some of the finer grained Gaylard and lower Gething facies contain freshwater bivalves and ostracodes, whereas others contain restricted marine foraminifers, indicating the presence of freshwater to marine depositional environments.

The last of the conspicuous lithofacies assemblages characteristic of the Gaylard Member and lower Gething Formation in the south consists of rhythmic or alternating thin units or beds of medium to medium light grey sandstone to siltstone and dark grey carbonaceous mudstone to shale (Figs. 21, 22, 34). In outcrop the strata weather as light and darker grey, resistant and recessive weathering couplets (Fig. 21). The sandstone is very fine grained and commonly grades upward into siltstone and mudstone or shale. The thin sandstones have erosional bases and contain wavy, lenticular to ripple lamination and microscale crossbedding (Figs. 22, 34). In the Williston Lake–Carbon Creek area in the north and the Sukunka River area to the south, sand-filled vertical and horizontal burrow traces, similar to *Skolithos* and *Planolites*, are common in the mudstones and siltstones. In addition, sand-filled syneresis cracks (Figs. 34, 35) probably formed in an environment characterized by variable or fluctuating salinities (Burst, 1965; Donovan and Foster, 1972; Collinson and Thompson, 1982; Mason and Christie, 1986). The internal structure and rhythmic sequence relationship suggest that the thin, fining-upward sandstone-siltstone beds probably represent fluvial flood discharges or storm-generated currents debouching into a standing body of water such as a fresh or brackish water lower delta plain lake, or brackish water interdistributary bay or estuary. Similar rhythmic facies occur in strata of the overlying Bullmoose Member, but appear to have been deposited in a more open marine shelf environment.

The rhythmic character of the sandstone-siltstone-mudstone lithofacies suggests that the depositional setting was characterized by intervals of quiescence during which time the clays, muds and silts were deposited from suspension, and burrowing, bioturbation mottling, and syneresis cracks became dominant. This tranquil phase was then interrupted by periods of storm activity and/or fluvial flood discharges, resulting in the deposition of the thin, graded sand in the lacustrine or brackish water bay environment by density currents. Where burrow traces, bioturbation and subaqueous syneresis cracks form quantitatively conspicuous structures in the strata, the environment appears to be one characterized by brackish to marine water, such as is found in lower delta plain interdistributary bays, coastal embayments or estuaries. In contrast, where these structures are absent or rare, the environment appears to have been one of fresh water and more typical of a flood basin lake. In the Carbon Creek area, some of the mudstones and siltstones have yielded marine and possible brackish water bivalves. Locally, these fossil-bearing strata are associated with thin seams of high-sulphur coals, supporting my contention that a marine to brackish marine depositional environment was involved (Gibson, 1985a).

The composition, distribution, thickness and lateral continuity of coal seams may be used to assist in the interpretation of some depositional environments as postulated by Horne and Fern (1976), Riegel (1977), Collins (1977), and Weimer (1977). For example, these authors have shown that coals characterized by low sulphur concentrations are interpreted as having formed from peats associated with freshwater swamps and marshes. Conversely, coals containing relatively high concentrations of sulphur may have formed in swamp and marsh environments subject to marine or brackish water contamination. In an earlier study, the writer examined the sulphur concentration of several Gething Formation Gaylard Member coal seams in the Carbon Creek Basin, recording values ranging from 0.32 to 7.2 per cent (Gibson, 1985a). Most seams, however, have sulphur contents of less than 1 per cent, suggesting peat accumulation under freshwater conditions. However, several seams in the upper part of the formation contain in excess of 1 per cent sulphur, suggesting peat accumulation in or adjacent to a marginal marine to brackish water environment (Gibson, op. cit.). Elsewhere, random coal sample analyses, plus analytical values obtained from coal company personnel and company exploration reports, indicate generally low sulphur concentrations, suggesting peat accumulation in a predominantly freshwater swamp or marsh environment. However, at Pink Mountain (Fig. 10), some sulphur values, ranging from 1.12 to 2.80 per cent, were recorded, suggesting marine to brackish water conditions.

The distribution and thickness of coals in the Gaylard Member and lower Gething Formation are shown by Figures 3 to 10. Most seams are relatively thin although, locally, some are thick. As discussed above, most seams are laterally discontinuous, so that correlation between adjacent coal properties and even adjacent boreholes is often difficult or impossible. This characteristic, when combined with the variable coal sulphur values and other sedimentological and biological criteria, is in agreement with the lower delta plain interpretation postulated for most strata of the Gaylard Member. The delta plain environment is generally characterized by frequent shifting of distributary and crevasse channels and associated interfluvial floodplain and flood basin areas, so that peat accumulation is interrupted, resulting in the development of many relatively thin but locally numerous seams of coal (Fig. 9).

Bullmoose Member

Following deposition of the Gaylard Member, much of the area was subjected to a major transgressive-regressive pulse of the Clearwater–Moosebar Sea, during which time the Bullmoose strata were deposited. The regional transgression actually began in some areas during the late depositional stages of the Gaylard Member, as shown by the marine foraminifers in mudstone facies near the top of the member in the Sukunka area (Fig. 6). The transgression is best illustrated by the general coarsening-upward character, and the marine foraminifers and bivalves in the Bullmoose Member. In addition to the general or main coarsening-upward trend throughout the Bullmoose, the interval in the Sukunka River–Bullmoose Mountain area also displays up to three secondary coarsening-upward trends, reflecting secondary pulses of the Clearwater–Moosebar transgression and regression

(Fig. 7). Capping the lowermost of the secondary coarsening-upward trends is a fine to coarse grained to conglomeratic, glauconitic sandstone, reflecting a probable depositional hiatus and transgressive event.

In the Monkman–Stony Lake area to the south, the Bullmoose Member is thin (Figs. 5, 45) and evidence of the transgression is not as apparent. The strata display wavy to lenticular bedding, abundant bioturbation, and burrow traces, some of which are filled by grains or crystals of pyrite. At the Petro-Canada 81-04 borehole (Appendix 2), foraminifers and one branchiopod, collected by D.A. Leckie of the Geological Survey, indicate a shallow water, restricted marine environment; one in which the salinity was reduced. Furthermore, some of the boreholes contain a thin, transgressive, conglomeratic sandstone to pebble conglomerate marker horizon, again suggesting a depositional hiatus and a marine transgressive event (Figs. 5, 45, 46). Available evidence, therefore, suggests that the Monkman–Stony Lake area represents the southern limit in the Foothills of the transgressive pulse of the boreal Clearwater–Moosebar Sea. This area is envisioned as a large delta plain characterized by large and small estuaries or interdistributary bays with small wave-dominated strandplains locally, and with restricted but open connections to the sea. As noted above, Oppelt (1986) recorded evidence of marine strata that may be equivalent to the Bullmoose Member, as far south as the Wapiti River area. North and northeast of the Sukunka River area the Bullmoose Member grades laterally into marine mudstones and siltstones of the Moosebar Formation (Fig. 7).

Rhythmic or alternating thin units of very fine grained sandstone to siltstone and thin to relatively thick units of mudstone characterize the Bullmoose succession (Figs. 43, 44). The mudstones represent fairweather suspension strata deposited mainly below fairweather wave base. They are dark grey, may contain grains, crystals and thin laminae of pyrite, and are generally highly bioturbated, displaying in part well preserved burrow traces similar to *Skolithos*, *Planolites*, *Chondrites* and *Helminthopsis* or *Helminthoida* (Fig. 47). It has been suggested (Bromley and Ekdale, 1984) that the occurrence of *Chondrites* indicates an anaerobic depositional environment. Pyrite in some of the mudstones also reflects an anaerobic reducing environment. The *Helminthoida* or *Helminthopsis* traces, which appear in cross-section as small angular chips or flakes of mudstone, ranging from 2 to 5 mm in diameter (Fig. 47), have also been recognized in strata of the overlying marine Moosebar Formation by Leckie and Walker (1982) and Carmichael (1983), and thus add support to the interpretation of a marine environment for the Bullmoose Member. Foraminifers, bivalves, and several dinoflagellate genera were identified from the mudstones, again indicating a marine depositional environment. The volume or percentage of mudstone decreases upward in both the main coarsening-upward profile and in each of the secondary coarsening-upward cycles in the Sukunka River area (Figs. 6, 7), indicating a shallowing of the marine environment and increasing proximity to the shoreline.

The conspicuous lighter grey sandstone to siltstone interbeds are generally characterized by a sharp erosional base grading upward into finer grained siltstone and darker grey to black mudstone (Figs. 43, 44, 47). The beds display well developed parallel, and ripple lamination and, in some of the thicker beds near the top of the succession and Chamberlain Member contact, very shallow, festoon-like crosslaminae that probably represent hummocky crossbedding. These primary structures were observed in core and outcrop in the Sukunka–Bullmoose Mountain area. Most beds, particularly those near the base of the Bullmoose Member, are burrowed, containing such burrow traces as *Planolites*, *Skolithos* and possible *Teichichnus*. The thickness, fining-upward character and internal structure of the sandstone-siltstone beds suggest that they represent tempestites (Brenchley, 1985) or turbidites, emplaced onto a marine shelf by storm- or wind-generated waves and currents or by strong storm surge and subsequent turbidity ebb currents. In some areas the beds may have resulted from fluvial flood pulses discharging into a prodelta. Sedimentary structures typical of classical Bouma (1962) turbidites were not observed in the facies by the writer. However, Leckie and Walker (1982) described similar sandstone-siltstone strata in correlative mudstone units of the Moosebar Formation. Because some of the beds displayed the Bouma divisions, they interpreted them as turbidites.

The appraisal of water depths within the Bullmoose shelf environment is somewhat speculative. The lithological character of the thin bedded tempestites and/or turbidites suggests that the first sediments to be deposited during the major transgressive–regressive cycle were deposited at depths close to or slightly below storm wave base. If these sediments were deposited above storm wave base one might expect the development of abundant hummocky crossbedding, a structure generally related to storm wave activity between storm and fairweather wave base (Leckie and Walker, 1982). Hummocky crossbeds were not observed in the thinner bedded rhythmic sandstone-siltstone-mudstone facies. As the Bullmoose regression continued, the shelf seas shallowed, and shoreface sandstones began to develop in the upper part of the Bullmoose Member. Some of these sandstones contain small-scale, shallow-troughed crossbeds which probably represent hummocky crossbeds deposited between storm and fairweather wave base. As noted above, the major regional regression was interrupted locally by up to three brief transgressive pulses during which the small secondary coarsening-upward profiles were developed.

Leckie and Walker (1982) and Carmichael (1983) described and discussed a regional coarsening-upward trend from relatively deep water sandstones, siltstones and shales of the Moosebar Formation into shallower water shoreface and beach sandstones and delta plain strata of the overlying Gates Formation. As noted and discussed above, strata of the Bullmoose Member represent a stratigraphically lower tongue of the Moosebar Formation. Accordingly, because of a similar transitional facies between Bullmoose and Chamberlain strata, one might expect similar lithofacies and sedimentary structures. Leckie and Walker (op. cit.) and Carmichael (op. cit.) noted that turbidites and hummocky crossbeds are common in the transitional facies. In addition, Leckie and Walker documented the occurrence of another primary structure which they called swaley crossbedding. They interpreted the swaley crossbeds as being diagnostic of shoreface environments located above fairweather wave base. In the Bullmoose/Chamberlain transitional facies, hummocky crossbedding was observed near the top of the Bullmoose Member in core and outcrop in the Sukunka-Bullmoose Mountain area. It would appear that, unlike the overlying Moosebar-Gates Formation transitional facies (where deposition took place in an open marine, wave-dominated coastal environment), strata of the Bullmoose Formation in most of the report area were probably deposited in a shallower water, less open marine environment, perhaps one adjacent to large coastal estuaries or interdistributary bays. Alternatively, the transitional Bullmoose strata may represent an open marine seaward facies of the overlying Chamberlain Member shoreface sandstones.

In the Monkman-Stony Lake area (Fig. 5), Bullmoose strata display, in part, a similar lithological character to those in the north, although the succession is much thinner and the coarsening-upward profile is not evident. Thin, pebbly sandstone units (Figs. 45, 46) were noted in four boreholes in the Monkman area and a transgressive pebble conglomerate has been observed in outcrop near Five Cabin Creek by Kilby (pers. comm., 1986). The foraminifers and single branchiopod recorded by D.A. Leckie from the Bullmoose interval in the Monkman area indicate a shallow marine, possibly brackish water depositional environment (Wall, pers. comm.; Appendix 2), perhaps one adjacent to or within a large interdistributary bay or estuary, where water salinities were diluted by fluvial waters from the delta.

Noteworthy thin to thick beds of fine to coarse grained to conglomeratic sandstone "cap" the secondary coarsening-upward units in the Sukunka River area (Fig. 7). Locally, the sandstone is conglomeratic with well rounded pebbles in a matrix of greenish grey, fine to coarse grained, glauconitic, quartz sandstone. Angular, dark grey mudstone, rip-up clasts; rare coalspars; and very shallow-troughed festoon crossbeds and/or possible hummocky crossbeds were noted in some cores and at the outcrop locality at Bullmoose Mountain. The sedimentary character and composition of these beds suggest that they represent a transgressive marine sandstone. A similar but thinner transgressive marine sandstone was noted in the Monkman area to the south, although in that area glauconite was not observed (Figs. 45, 46).

Chamberlain Member

The Chamberlain Member and upper part of the undifferentiated Gething Formation in the south are depicted as having formed part of a north to northeasterly prograding clastic wedge, deposited during a temporary regressive stage of the southerly transgressing boreal Clearwater-Moosebar Sea (Figs. 7, 12). Stratigraphic and sedimentological relationships, when combined with data on the microfauna, macrofauna, microflora and ichnogenera, suggest that most strata of the Chamberlain Member were deposited in a storm- or wave-dominated lower delta plain, characterized by lithofacies of shoreface-beach, estuary and/or lagoon, coastal swamp or marsh, and distributary channel origin. In addition, strata of braided stream and possible fan delta origin occur in the Monkman-Stony Lake and immediately adjacent areas (Fig. 5). In the Belcourt, Narraway and Smoky rivers area farther south, undifferentiated upper Gething, and the laterally equivalent upper Gladstone Formation, contain strata of lower delta plain distributary and crevasse splay channels; overbank floodplains; and brackish marine, estuary or interdistributary bay depositional environments. Possible beach-shoreface strata were observed near Grande Cache.

The Chamberlain Member is characterized by several thick sandstone and conglomeratic sandstone units (Figs. 5, 6), which display parallel to low-angle divergent laminae, and in outcrop contain medium- to small-scale, shallow-troughed crossbeds that may, in part, represent swaley crossbeds (Fig. 59). In the Sukunka River area, well preserved trace fossils of *Planolites*, *Paleophycus* and *Macaronichnus segregatus* occur in the sandstone facies (Figs. 62, 63). In the Monkman area, however, only *Planolites* and *Teichichnus* were observed (Fig. 60).

Stratigraphic relationships, sedimentary structures and, most importantly, the trace fossils, are evidence that most thick sandstone units of the Chamberlain Member, particularly in the Sukunka area, were deposited as part of a storm-dominated, beach-shoreface depositional environment. In this area, these shoreface sandstones, including the basal sandstone of the member, may have formed part of a barrier island complex, bounded shoreward by lagoons or large lagoonal estuaries similar in character to those in existence today off the eastern coast of the United States (Staub and Cohen, 1979; Howard and Frey, 1985). The occurrence of several beach-shoreface sandstones in the Chamberlain Member of the Sukunka River area suggests a fluctuating sea level in the area, resulting in local transgressions and regressions. A similar, storm-dominated shoreface depositional setting has been proposed by Leckie and Walker (1982), Carmichael (1983), and Cant (1984) for basal sandstones of the Gates and Fahler formations of the overlying Fort St. John Group in northeastern British Columbia and west-central Alberta. Effects of these transgressions and regressions were not, however, recorded in most of the Chamberlain strata of the Monkman–Stony Lake area, where the thick conglomerate and conglomeratic sandstones appear to be mainly of fluvial origin.

The occurrence of the trace fossils *Macaronichnus segregatus* and *Paleophycus* in the basal sandstone and other thick sandstones of the Chamberlain Member in the Sukunka River area (Figs. 62, 63), support the interpretation of a marine shoreface depositional environment. *Macaronichnus segregatus* traces were probably formed by polychaetes in a shallow marine, intertidal or subtidal depositional environment (Clifton and Thompson, 1978; Leckie and Walker, 1982; Carmichael, 1983).

All of the *Paleophycus* traces observed by the writer in the Chamberlain sandstones invariably occur below traces of *Macaronichnus segregatus*, suggesting that the former are diagnostic of a relatively high energy lower shoreface, but slightly deeper water, depositional environment, similar to the environmental relationships of this trace fossil noted in the shoreface sandstones of the Fahler Formation (Cant, 1984).

In addition to the prominent beach-shoreface sandstones in the Chamberlain of the Sukunka area, another conspicuous but local sandstone facies was recorded above the Chamberlain coal seam interval at borehole locality BP 53 (Fig. 6). This is fining-upward (medium to fine grained) sandstone, characterized by medium- to small-scale, festoon crossbedding, distorted laminae and ripple lamination. Conspicuous vitreous coalspars occur near the base. It represents a locally developed distributary channel. Burrows and bioturbation mottling were not observed, thus supporting the nonmarine distributary channel interpretation. Similar distributary channel sandstones were recorded in three petroleum exploration boreholes, illustrated in Figure 6.

The thick, coarser grained sandstone, conglomeratic sandstone, and chert-pebble conglomerate units of the Chamberlain Member in the Monkman–Stony Lake area are interpreted as mainly facies of braided stream and distributary channel depositional environments, although the basal sandstone of the Chamberlain Member in part of the area represents a probable beach-shoreface environment (Fig. 45). The coarser grained and conglomeratic sandstone units are moderately to poorly sorted, and commonly display fining-upward grain size trends (Figs. 49, 50). Small- to medium-scale festoon crossbeds, ripple and ripple drift lamination, and contorted laminae are common in the finer grained facies of the units. Coalspars, and angular, dark grey mudstone rip-up clasts, and less common wood moulds and casts are conspicuous in some of the coarser grained and conglomeratic facies (Fig. 51). The conglomerate is predominantly clast supported, occurring as lenses, and as thin to thick beds within the thick sandstone units. Most sandstones display erosional bases. At some localities, small horizontal and vertical burrow traces were noted in the finer grained sandstones near the top of the thicker units. Most of these sedimentary characteristics are consistent with a fluvial origin for this facies. The coarse granularity and relatively poor sorting of the facies suggest a depositional setting dominated by large and small braided streams or rivers. Alternatively, the strata may represent facies of coarse grained to conglomeratic meandering channels. The presence of rare burrow traces and the close relationship with finer grained siltstones and mudstones of probable brackish water origin, suggest that, locally, the coarse clastic material may have been deposited as part of a small local fan delta prograding into the brackish water of a coastal bay. The thick chert-pebble conglomerate and conglomeratic sandstone at the top of the Chamberlain Member in the region contain sedimentary structures and display facies relationships similar in character to those lower in the member. Accordingly, a similar braided channel depositional setting is suggested for the top of the Chamberlain in the Monkman-Stony Lake area.

In the remainder of the Monkman-Stony Lake area where strata of the Gething Formation are not subdivided, most of the thicker bedded, fine to coarse grained sandstones of the upper Gething Formation have erosional bases, fining-upward grain size trends, and small-scale to rare medium-scale festoon crossbedding; all of which suggest delta plain distributary channels. However, at some localities illustrated in Figure 5b, sandstones with conspicuous grains of glauconite were recorded, suggesting a possible marine influence. Accordingly, they may represent distributary mouth bars. The thinner bedded, coarser grained sandstone units are interpreted as crevasse splay deposits.

In the Grande Cache-Smoky River area, the uppermost facies of the correlative Gladstone Formation is characterized by very fine grained sandstone to siltstone, and dark grey mudstone to shale with abundant burrow traces, gradationally overlain by a conspicuous fine to medium grained sandstone (Fig. 3). The capping sandstone contains vertical *Skolithos*-like burrow traces and displays parallel to low-angle, divergent laminae and some well developed planar/tabular crossbedding. The coarsening-upward character, sedimentary structures, and stratigraphic relationships are evidence that this sandstone also may represent a local shoreface-beach environment, developed along the margin of a coastal bay, such as a brackish water estuary or interdistributary bay. Alternatively, the sandstone may represent a distributary mouth bar.

Interspersed with the coarser grained sandstones and conglomerates of the Chamberlain Member are thinner bedded units composed of sandstone, siltstone, and mudstone to shale; coaly, carbonaceous siltstone and mudstone; and thin to thick seams of coal (Figs. 5, 6). In the Burnt-Sukunka rivers area, the basal shoreface sandstone is overlain by an interval of rhythmic, wavy to lenticular beds of sandstone to coarse siltstone and dark grey mudstone. Rare *Paleophycus*-like and other small horizontal and vertical burrow traces occur in some of the thin bedded sandstones. Similarly, the associated siltstones and mudstones are burrowed and bioturbated, with *Planolites* burrows common. At the BP 53 borehole (Figs. 6, 7), *Helminthopsis*-like burrow traces were observed (Fig. 52). Mudstone samples from this locality yielded foraminifers, pelecypods and ostracodes, which indicate a shallow water marine environment. In addition, subaqueous syneresis cracks have penetrated many of the mudstone couplets (Fig. 54). The lithofacies association, occurrences of a marginal marine microfauna, and presence of subaqueous syneresis cracks, suggest that the strata were deposited in a standing body of marine to brackish water, subjected to storms or fluvial flood pulses, during which the graded, thin bedded sandstone and siltstone units were deposited in the basin. The occurrence of syneresis cracks is generally assumed to be indicative of variable water salinities, a feature common to back barrier lagoons, estuaries or interdistributary bays, where fresh water from rivers or streams would dilute the salinity of the seawater. If one assumes a coastal barrier or barrier island depositional environment for the underlying basal sandstone, the overlying bioturbated facies may represent strata of a back barrier lagoon or large lagoonal estuary, similar in character to those along the eastern seaboard of the United States.

The Chamberlain Coal Seam interval in the Sukunka River area comprises carbonaceous and coaly siltstone, mudstone, rare very fine grained sandstone, and up to two thick seams of coal. The siltstones and mudstones locally contain small *Planolites*-like burrow traces and display wavy, ripple, and distorted convolute laminae. The strata, including the coal seams, overlie another thick shoreface-beach sandstone and are interpreted as having formed part of a lower delta plain, coastal swamp or marsh environment. If, however, the shoreface-beach sandstones formed part of a barrier island sequence, the coal and coaly facies more likely would represent strata of a back barrier lagoon or lagoonal estuary. The occurrence of burrow traces and bioturbation mottling is suggestive of local brackish water conditions during deposition of the sediments and formation of peat.

In the Monkman-Stony Lake area, strata above the Chamberlain basal sandstone consist mainly of carbonaceous mudstone and siltstone, rare thin beds of sandstone and/or thin to thick seams of coal (Fig. 5). It would appear that in this area the presence of the coaly facies is characteristic of a lower delta plain, coastal swamp or marsh environment developed landward of a coastal shoreface-beach environment. Evidence of marine or brackish water inundations is lacking in the coaly facies. Similar lithofacies occur in other intervals above the thick sandstone, conglomeratic sandstone and conglomerate of the member (Fig. 5). Likewise, they are interpreted as facies characteristic of lower delta plain overbank, crevasse splay, and flood basin subenvironments. Locally, however, the siltstones and mudstones contain *Skolithos* and *Planolites*-like traces, and mudstones from the Pacific MDD 77-3 borehole yielded foraminifers and dinoflagellates. This biogenic evidence is indicative of marginal marine to brackish water depositional conditions, thus supporting the writer's contention that some of the finer grained siltstones and mudstones are the products of estuary or interdistributary bay depositional environments.

In the petroleum exploration wells and some coal exploration boreholes where core is unavailable, and where the Gething Formation is undifferentiated (Fig. 5), the finer grained sandstones, siltstones, mudstones, and thin to thick seams of coal, display facies relationships characteristic of lower delta plain subenvironments.

In the Dumbgoat Mountain and Mount Torrens areas (Figs. 3, 4, 16, 64), evidence suggestive of marine or brackish water inundations is lacking. It is possible, therefore, that the strata may have been deposited higher on the delta plain in an upper delta plain environment.

In the Grande Cache–Smoky River area (Figs. 3, 65), strata of the upper Gladstone Formation are characterized by several thin intervals of siltstone, mudstone and shale, with well developed burrow traces of *Diplocraterion* and *Arenicolites* (Jerzykiewicz and Langenberg, 1983). In addition, the bivalve *Protocardium* sp. and a poorly preserved foraminifer have been recovered from mudstone of the upper Gladstone Formation (Jerzykiewicz and Langenberg, op. cit.). The burrow traces and fossils indicate a brackish or marine environment.

Following deposition of the Chamberlain Member and upper strata of the undifferentiated Gething and Gladstone formations, the region was subjected to a major transgression of the boreal Clearwater–Moosebar Sea, during which time strata of the Moosebar Formation were deposited. Unlike the transgression during which strata of the Bullmoose Member were deposited, this transgression was of regional significance, extending throughout all areas of northeastern British Columbia and most areas of west-central Alberta, and as far south as northern Montana (Hopkins et al., 1982; Burden, 1984; and Banerjee, 1986).

ECONOMIC GEOLOGY

Strata of the Gething Formation have long been recognized as a potentially important source of coal and, in recent years, as potential reservoirs for oil and natural gas. Coal resource estimates for the Gething in the northern inner Foothills indicate that measured resources of immediate interest are in the order of 300 megatonnes (British Columbia Geological Survey Branch, W. Kilby, pers. comm., 1987). Hydrocarbon reserves in the area are unknown, although in the Deep Basin area of the Alberta and British Columbia Plains to the east, established reserves of 117 billion cubic feet of gas have been calculated for the Gething Formation (Smith et al., 1984). In the same area, the combined Gething and Bluesky formations have been assessed as containing 268.6 billion cubic feet of gas (Smith, 1984). It would appear, therefore, that the Gething Formation in the report area not only serves as an important source of coal but may also serve as a potential target and source for hydrocarbons.

Coal

In recent years the Gething Formation has been actively explored in the Carbon Creek Basin, Peace River–Mount Gething area, Pine River valley area, and the Burnt–Sukunka rivers area as a source of metallurgical coal. In the Foothills south of Sukunka River the formation has not been a prime target for coal. Interest in this southern area has been directed toward coals in the overlying Gates Formation. However, as noted previously, the Gething in the south contains several seams that will serve as prospects for future development and exploitation.

Gaylard Member

The Gaylard Member throughout most of the area contains many coals seams, although many are thin and probably not of immediate economic interest. In the Carbon Creek Basin, where the member is over 1100 m thick, in excess of 100 seams were recorded by Gibson (1985a). However, only 10 to 14 of these seams are of sufficient thickness to be of immediate economic interest. Most coal in the Gaylard is medium to high volatile bituminous in rank.

In the Peace River–Williston Lake area of the inner Foothills, Gaylard strata contain several seams ranging from 1 to 1.5 m in thickness (Fig. 9). The coals display mean maximum reflectance values that range from 0.93% to 1.45% Rmax, indicating A.S.T.M. ranks of high to medium volatile bituminous. In the inner Foothills to the north, strata of the Gaylard become increasingly more marine to brackish in origin, and the coals are thin and contain sulphur in concentrations up to 2.80%. In this region, the coal seams do not appear to be of economic value.

In the Pine River area, the Gaylard Member contains several thick coal seams in the upper half of the member (Figs. 7, 8). For example, at the Gulf Goodrich 81-06 borehole (Fig. 7), one coal zone near the top of the borehole is 19 m thick; however, the coal interval contains some thin, coaly shale and mudstone partings. Reflectance values in the area range from 1.04% to 1.81% Rmax, indicating A.S.T.M. coal ranks of high to low volatile bituminous. Medium volatile bituminous coal forms the dominant rank. In the Burnt–Sukunka rivers area immediately to the south, up to five seams of economic thickness occur in the Gaylard Member (Fig. 6). They range from 1 to 3.7 m in thickness and range in rank from low to medium volatile bituminous.

In the Monkman–Stony Lake area, Gaylard seams are generally thin, although a few range in thickness from 0.5 to 2.13 m. Coal reflectance values range from 1.24% to 1.60% Rmax, indicating coals of medium to low volatile bituminous rank. Most Gaylard coal in the area is of medium volatile bituminous rank.

Bullmoose Member

Because of the marine to marginal marine character of the strata, the Bullmoose Member does not contain coal of economic interest.

Chamberlain Member

Coal in the Chamberlain Member is limited to the inner Foothills belt between Sukunka River and the Monkman–Stony Lake area (Figs. 5, 6). It appears to have the best potential for exploitation in the Gething succession. In the Sukunka River area, the Chamberlain contains three main coal-bearing intervals which, in descending order, have been named the Bird, Skeeter, and Chamberlain seams (Fig. 6). The Bird Seam attains a maximum thickness of 3 m with an A.S.T.M. rank of medium volatile bituminous coal. Unfortunately, because of its proximity to the overlying marine Moosebar Formation, it may have a relatively high sulphur content. At one locality, chemical analysis revealed a sulphur concentration of 3.03%. The Skeeter Seam, an upper split of the Chamberlain Seam, ranges in thickness from 0.39 to 2 m, although, in some areas, it has been reported that it attains a thickness of 3.9 m (Duff and Gilchrist, 1981). Reflectance values range from 1.41% to 1.27% Rmax, indicating coal of medium volatile bituminous rank. The lowest and economically most promising seam is the Chamberlain, which, in the Sukunka River–Bullmoose Mountain area, ranges from 1.8 to 3.1 m thick. It has the rank of medium volatile bituminous coal. Its distribution in the area appears to be widespread, and it possibly extends as far south as the Monkman–Stony Lake area. In the Monkman–Stony Lake area, two prominent seams characterize the member (Fig. 5). They range in thickness from 0.32 to 4.65 m and have reflectance values that range from 1.19% to 1.48% Rmax, indicating coal of medium volatile bituminous rank. As noted above, these seams may be correlative with the Skeeter and Chamberlain seams to the north.

Undifferentiated Gething Formation

South of the Monkman–Stony Lake area, the Gething succession cannot be subdivided into its component members. In this area, the formation is relatively thin and, accordingly, seams are not as numerous as in the north. The best coals occur in the lower half of the formation and seams range from 20 cm to 6.4 m in thickness (Fig. 5b). In the inner Foothills the seams range from 0.81% to 1.46% Rmax, indicating coals of high to low volatile bituminous rank.

In the Grande Cache area, coals in the equivalent Gladstone Formation are both erratic in distribution and in thickness, although in some areas there is a potential for economic development (Fig. 3). In the Gustavs Flats area up to six seams occur in the Gladstone Formation, with thicknesses ranging from 0.64 to 4.1 m. The coal is mainly of low volatile bituminous rank.

Oil and Gas

Strata of the Gething, Cadomin and Bluesky formations serve as important oil and gas reservoirs in the Deep Basin area of west-central Alberta and northeastern British Columbia (Stott, 1973; Masters, 1984; Smith et al. 1984; Smith, 1984; Varley, 1984). This area, a part of the Interior Platform and Plains, lies adjacent to and east of the present study area. To date, hydrocarbons from the Deep Basin consist mainly of gas, produced from mainly fluvial-alluvial fan strata of the Cadomin Formation. However, significant production also has been obtained from fluvial channel and tidally reworked barrier bars of the Gething and Bluesky formations respectively (Smith et al., 1984). Gething strata reportedly contain established gas reserves of 117 Bcf, those of the Bluesky 98 Bcf, and those of the Cadomin Formation 1160 Bcf (Smith et al., op. cit.). The possibility of similar, gas saturated sands occurring in the Gething and Cadomin formations in the Foothills to the west is low, because most of the report area is within the deformed belt where the Lower Cretaceous stratigraphic succession is folded and faulted and, accordingly, lies relatively close to surface. Kalkreuth and McMechan (1984) have shown that the western part of the inner Foothills belt north of Grande Cache displays levels of thermal maturation which indicate that, under suitable stratigraphic and/or structural conditions, this area could contain hydrocarbons.

The best reservoir targets in the Gething Formation are probably the thick shoreface and fluvial sandstones of the Chamberlain Member. These rocks are fine to coarse grained to conglomeratic, generally well sorted, and appear to contain good porosity. They occur above potential source rock siltstone and shale of the Bullmoose Member, and pinch out or grade laterally into marine shale of the Moosebar Formation. Furthermore, the sandstones and conglomerates are associated with relatively thick seams of coal, which themselves may contain or generate methane gas (Wyman, 1984). Additional potential reservoir facies in the Gething include the thick channel sandstones and conglomerates in the Gaylard Member in the vicinity and north of Williston Lake, and those in the undifferentiated lower and upper Gething strata south of the Monkman–Stony Lake area.

Because of the coal seams, the Gething Formation may also serve as an economically important source of methane gas. Masters (1984), Welte et al. (1984), Wyman (1984), and Varley (1984) have suggested that coal measures in the Deep Basin area are an important source of natural gas for many of the producing reservoirs. For example, Wyman (op. cit.) estimated that Lower Cretaceous rocks in the Elmworth area of the Deep Basin, can yield as much as 500 cubic feet of methane per ton of coal. Coal resource estimates in the area suggest that the Lower Cretaceous coals may contain about 50 Tcf of methane in place. Under similar entrapment conditions in the report area (to the west of the Elmworth area), the Gething Formation coals could also yield high methane concentrations. Unfortunately, as noted above, most of the Gething succession in the report area occurs within the deformed Foothills belt and may not be buried deeply enough to contain or entrap the methane gas. Toward the eastern margin of the outer Foothills, the formation may be a potential and more promising reservoir target.

REFERENCES

Alberta Study Group
1954: Lower Cretaceous of the Peace River region. *In* Western Canada Sedimentary Basin, Rutherford Memorial Volume, L.M. Clark (ed.); American Association of Petroleum Geologists, Tulsa, Oklahoma, p. 268-278.

Badgley, P.C.
1952: Notes on the subsurface stratigraphy and oil and gas geology of the Lower Cretaceous Series in Central Alberta. Geological Survey of Canada, Paper 52-11.

Banerjee, I.
1986: Lower Mannville sedimentation in the "Edmonton Channel", central Alberta. *In* Current Research, Part B, Geological Survey of Canada, Paper 86-1B, p. 383-397.

Beach, H.H. and Spivak, J.
1944: Dunlevy-Portage Mountain map-area, British Columbia. Geological Survey of Canada, Paper 44-19 (includes geological map; 1 inch to 1 mile).

Bell, W.A.
1956: Lower Cretaceous floras of Western Canada. Geological Survey of Canada, Memoir 285, 331 p.

Bernard, H.A., Major, D.F. Sr., Parrott, B.S., and LeBlanc, R.J. Sr.
1973: Recent sediments of southeast Texas, a field guide to the Brazos alluvial and deltaic plains and the Galveston barrier island complex. Bureau of Economic Geology, University of Texas at Austin, Guidebook 11.

Bouma, A.H.
1962: Sedimentology of Some Flysch Deposits: A Graphic Approach to Facies Interpretation. Elsevier Publishing Company, Amsterdam, 168 p.

Brenchley, P.J.
1985: Storm influenced sandstone beds. Modern Geology, v. 9, p. 369-396.

Bromley, R.G. and Ekdale, A.A.
1984: *Chondrites*: a trace fossil indicator of anoxia in sediments. Science, v. 224, p. 872-874.

Burden, E.T.
1984: Terrestrial palynomorph biostratigraphy of the lower part of the Mannville Group (Lower Cretaceous), Alberta and Montana. *In* The Mesozoic of Middle North America, D.F. Stott and D.J. Glass (eds.); Canadian Society of Petroleum Geologists, Memoir 9, p. 249-269.

Burst, J.F.
1965: Subaqueously formed shrinkage cracks in clay. Journal of Sedimentary Petrology, v. 35, no. 2, p. 348-353.

Caldwell, W.G.E., North, B.R., Stelck, C.R., and Wall, J.H.
1978: A foraminiferal zonal scheme for the Cretaceous System in the Interior Plains of Canada. *In* Western and Arctic Canadian Biostratigraphy, C.R. Stelck and B.D.E. Chatterton (eds.); Geological Association of Canada, Special Paper 18, p. 495-575.

Cant, D.J.
1984: Development of shoreline-shelf sand bodies in a Cretaceous epeiric sea deposit. Journal of Sedimentary Petrology, v. 54, no. 2, p. 541-556.

Carmichael, S.M.M.
1983: Sedimentology of the Lower Cretaceous Gates and Moosebar formations, northeast coalfields, British Columbia. Ph.D. thesis, University of British Columbia, 285 p.

Chamney, T.P.
1973: Microfauna of Gething Formation. *In* Lower Cretaceous Bullhead Group between Bullmoose Mountain and Tetsa River, Rocky Mountain Foothills, northeastern British Columbia, D.F. Stott; Geological Survey of Canada, Bulletin 219, p. 67-71.

Clifton, H.E. and Thompson, J.K.
1978: *Macaronichnus segregatis*: a feeding structure of shallow marine Polychaetes. Journal of Sedimentary Petrology, v. 48, no. 4, p. 1293-1302.

Coleman, J.M. and Wright, L.D.
1975: Modern river deltas: variability of processes and sand bodies. *In* Deltas, 2nd edition, M.L. Broussand (ed.); Houston Geological Society, Houston, Texas, p. 99-150.

Collins, B.A.
1977: Coal deposits of the eastern Piceance Basin. *In* Geology of Rocky Mountain coal, Proceedings of the 1976 Symposium, Resource series 1, D.K. Murray (ed.); Colorado Geological Survey, Department of Natural Resources, State of Colorado, 1977, 175 p.

Collinson, J.D. and Thompson, D.B.
1982: Sedimentary Structures. George Allen and Unwin, London, Boston and Sydney, 140 p.

Dawson, G.M.
1881: Report on an exploration from Port Simpson on the Pacific Coast, to Edmonton on the Saskatchewan, embracing a portion of the northern part of British Columbia and the Peace River country. Geological and National History Survey of Canada, Report of Progress 1879-80, Part B, p. 1-177.

Donovan, R.M. and Foster, R.J.
1972: Subaqueous shrinkage cracks from the Caithness flagstone series (Middle Devonian) of northeast Scotland. Journal of Sedimentary Petrology, v. 42, p. 309-317.

Duff, P.McL.D.
1978: Correlation studies in the Peace River Coalfield. *In* Geological Fieldwork, 1977; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1978-1, p. 60.

1979: Correlation studies in the Peace River Coalfield. *In* Geological Fieldwork, 1978; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1979-1, p. 86.

Duff, P.McL.D. and Gilchrist, R.D.
1981: Correlation of Lower Cretaceous coal measures, Peace River Coalfield, British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1981-3.

Elliott, T.
1974: Interdistributary bay sequences and their genesis. Sedimentology, v. 21, p. 611-622.

1978: Deltas. *In* Sedimentary Environments and Facies, H.G. Reading (ed.); Elsevier, New York, p. 97-142.

Ethridge, F.G., Jackson, T.J., and Youngberg, A.D.
1981: Floodbasin sequence of a fine-grained meander belt system: the coal-bearing Lower Wasatch and Upper Fort Union formations, Southern Powder River Basin, Wyoming. *In* Recent and Ancient Nonmarine Depositional Environments: Models for Exploitation, F.G. Ethridge and R.M. Flores (eds.); Society of Economic Paleontologists and Mineralogists, Special Publication 31, p. 191-209.

Galloway, C.F.J.
1913: The coal measures of Peace River Canyon. British Columbia Minister of Mines, Annual Report 1912, p. 125-136.

1915: Peace River coal area: coal fields of British Columbia. Geological Survey of Canada, Memoir 69.

Galloway, J.D.
1924: Carbon River field. British Columbia Minister of Mines, Annual Report 1923, p. 140, 141.

Galloway, W.E.
1975: Process framework for describing the morphological and stratigraphic evolution of deltaic depositional systems. *In* Deltas, 2nd edition, M.L. Broussard (ed.); Houston Geological Society, Houston, Texas, p. 87-98.

Galloway, W.E. and Hobday, D.K.
1983: Terrigenous Clastic Depositional Systems, Applications to Petroleum, Coal and Uranium Exploration. Springer-Verlag, New York, Berlin, Heidelberg, Tokyo, p. 81-111.

Gibson, D.W.
1985a: Stratigraphy and sedimentology of the Lower Cretaceous Gething Formation, Carbon Creek Coal Basin, northeastern British Columbia. Geological Survey of Canada, Paper 80-12.

1985b: Stratigraphy, sedimentology and depositional environments of the coal-bearing Jurassic-Cretaceous Kootenay Group, Alberta and British Columbia. Geological Survey of Canada, Bulletin 357.

Gilchrist, R.D.
1979: Burnt River area (93 P/4, 5). *In* Geological Fieldwork, 1978; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1979-1, p. 79-83.

1980: Wolverine-Hasler map area (93 I/14; 93 0/8; 93 P/3, 4, 5). *In* Geological Fieldwork, 1979; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1980-1, p. 101, 102.

Gilchrist, R.D., Flynn, B.P., and Hauser, R.L.
1978: Mount Spieker area. *In* Geological Fieldwork, 1977; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1978-1, p. 57-59.

Hacquebard, P.A. and Donaldson, J.R.
1974: Rank studies of coals in the Rocky Mountains and inner Foothills Belt, Canada. Geological Society of America, Special Paper 153, p. 75-94.

Hopkins, J.C., Hermanson, S.W., and Lawton, D.C.
1982: Morphology of channels and channel-sand bodies in the Glauconitic Sandstone Member (Upper Mannville), Little Bow area, Alberta. Bulletin of Canadian Petroleum Geology, v. 30, p. 274-285.

Horne, J.C. and Ferm, J.C.
1976: Carboniferous depositional environments in the Pocahontas Basin, eastern Kentucky and southern West Virginia, a field guide. Department of Geology, University of South Carolina, Columbia, South Carolina, 129 p.

Howard, J.D. and Frey, R.W.
1984: Characteristic trace fossils in nearshore to offshore sequences, Upper Cretaceous of east-central Utah. Canadian Journal of Earth Sciences, v. 21, p. 200-219.

1985: Physical and biogenic aspects of back barrier sedimentary sequences, Georgia Coast, U.S.A. Marine Geology, v. 63, p. 77-127.

Hughes, J.E.
1964: Jurassic and Cretaceous strata of the Bullhead succession in the Peace and Pine River Foothills. British Columbia Department of Mines and Petroleum Resources, Bulletin 51, 73 p.

1967: Geology of the Pine Valley, Mount Wabi to Solitude Mountain, northeastern British Columbia. British Columbia Department of Mines and Petroleum Resources, Bulletin 52, 137 p.

Jackson, P.C.
1984: Paleogeography of the Lower Cretaceous Mannville Group of Western Canada. *In* Deep Basin Gas, J.A. Masters (ed.); American Association of Petroleum Geologists, Memoir 38, p. 49-77.

Jerzykiewicz, T. and Langenberg, W.
1983: Structure, stratigraphy and sedimentary facies of the Paleocene and Lower Cretaceous coal-bearing strata in the Coalspur and Grande Cache areas, Alberta. Field Trip No. 9, The Mesozoic of Middle North America; Canadian Society of Petroleum Geologists Conference, May 8-13, 1983, Calgary, Alberta, 63 p.

Kalkreuth, W.D.
1982a: Preliminary results on rank and composition of coals from the Gething Formation north of Peace River, northeastern British Columbia. *In* Current Research, Part C, Geological Survey of Canada, Paper 82-1C, p. 65-69.

1982b: Rank and petrographic composition of selected Jurassic-Lower Cretaceous coals of British Columbia, Canada. Bulletin of Canadian Petroleum Geology, v. 30, no. 2, p. 112-139.

1988: Kanadische Kreidekohlen, Inkohlungsgrad und petrographische Zusammensetzung kanadischer Kreidekohlen in den Rocky Mountain Foothills von NE-British Columbia and Westzentralalberta. Erdöl und Kohle, Bd. 41, Heft 2, p. 61 – 70.

Kalkreuth, W.D. and McMechan, M.E.
1984: Regional pattern of thermal maturation as determined from coal-rank studies, Rocky Mountain Foothills and Front Ranges north of Grande Cache, Alberta—implications for petroleum exploration. Bulletin of Canadian Petroleum Geology, v. 32, no. 3, p. 249-271.

1988: Burial history and thermal maturity, Rocky Mountain Front Ranges, Foothills, and foreland, east-central British Columbia and adjacent Alberta, Canada. American Association of Petroleum Geologists, Bulletin, v. 72, no. 11, p. 1395-1410.

Karst, R.H.
1979a: Coal property examinations, Peace River Coalfield. *In* Geological Fieldwork, 1978; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1979-1, p. 67-72.

1979b: Vitrinite reflectance as a correlation tool in the Carbon Creek coal measures (93 O/10, 15). *In* Geological Fieldwork, 1978; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1979-1, p. 73-77.

1981: Correlation of the Lower Cretaceous stratigraphy of northeastern British Columbia from Foothills to Plains. *In* Geological Fieldwork, 1980; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1981-1, p. 79-89.

Karst, R.H. and White, G.V.
1980: Coal rank distribution within the Bluesky-Gething stratigraphic horizon of northeastern British Columbia (93 I, O, P). *In* Geological Fieldwork, 1979; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1980-1, p. 103-107.

Kauffman, E.G.
1979: Cretaceous. *In* Treatise on Invertebrate Paleontology, Part A, Introduction, Boulder, Colorado, Berggren, W.A., et al.; Geological Society of America and University of Kansas Press, p. A418-487.

Kilby, W.E.
1984a: Tonsteins and bentonites in northeast British Columbia (93 O, P, I). *In* Geological Fieldwork, 1983; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1984-1, p. 95-108.

1984b: The character of the Bluesky Formation in the Foothills of northeastern British Columbia (93 O, P, I). *In* Geological Fieldwork, 1983; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1984-1, p. 109-112.

1985: Tonstein and bentonite correlations in northeast British Columbia (93 O, P, I; 94 A). *In* Geological Fieldwork, 1984; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1985-1, p. 257-277.

Kilby, W.E. and Oppelt, H.P.
1985: Numerical depositional modelling—Gething Formation along the Peace River (93 O, 94 A, 94 B). *In* Geological Fieldwork, 1984; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1985-1, p. 233-249.

Langenberg, W.C. and McMechan, M.E.
1985: Lower Cretaceous Luscar Group (revised) of the northern and north-central Foothills of Alberta. Bulletin of Canadian Petroleum Geology, v. 33, no. 1, p. 1-11.

Leckie, D.A.
1983: Sedimentology of the Moosebar and Gates formations (Lower Cretaceous). Ph.D. thesis, McMaster University, Hamilton, Ontario, 515 p.

1986: Rates, controls, and sand-body geometries of transgressive-regressive cycles: Cretaceous Moosebar and Gates formations, British Columbia. American Association of Petroleum Geologists, Bulletin, v. 70, no. 5, p. 516-535.

Leckie, D.A. and Foscolos, A.E.
1986: Paleosols and late Albian sea level fluctuations, Boulder Creek Formation, some preliminary observations; Poster Session, Canada's Hydrocarbon Reserves for the 21st Century. Canadian Society of Petroleum Geologists, 1986 Convention, June 1-4, 1986, Program and Abstracts, p. 102.

Leckie, D.A. and Walker, R.G.
1982: Storm- and tide-dominated shorelines in Cretaceous Moosebar-Lower Gates interval—outcrop equivalents of Deep Basin gas trap in Western Canada. American Association of Petroleum Geologists Bulletin, v. 66, no. 2, p. 138-157.

Legun, A.
1983: Stratigraphy and sedimentology notes on the Bullhead Mountain-Peace River Canyon, Carbon Creek area, northeastern British Columbia (93 O/15, 16; 94 B/1, 2). *In* Geological Fieldwork, 1982; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1983-1, p. 92-97.

1984a: Stratigraphic and depositional relationships between the Bluesky marker unit, Gething marine tongue, and upper coal measures of the Gething Formation (93 O, P). *In* Geological Fieldwork, 1983; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1984-1, p. 117-122.

1984b: Geology of the Butler Ridge area (NTS 94 B/1) British Columbia. British Columbia Ministry of Energy, Mines and Petroleum Resources, Preliminary Map no. 57 with accompanying notes.

1984c: Butler Ridge map area, Peace River District (94 B/1). *In* Geological Fieldwork, 1983; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1984-1, p. 123-130.

1985a: Eastern limit of upper coal measures of the Gething Formation (Chamberlain member) Peace River Coalfield (93 P). *In* Geological Fieldwork, 1984; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1985-1, p. 250-255.

1985b: Geology of the West Carbon Creek area (93 O/15). *In* Geological Fieldwork, 1984; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1985-1, p. 227-232.

1986: Geology of the Carbon Creek area (93 O/15). *In* Geological Fieldwork, 1985, British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1986-1, p. 155-160.

Mason, T.R. and Christie, A.D.M.
1986: Paleoenvironmental significance of ichnogenus *Diplocraterion torrell* from the Permian Vryheid Formation of the Karoo Supergroup, South Africa. Palaeogeography, Palaeoclimatology, Palaeoecology, v. 52, p. 249-265.

Masters, J.A.
1984: Lower Cretaceous oil and gas in Western Canada. *In* Elmworth—Case study of a Deep Basin Gas Field, J.A. Masters (ed.); American Association of Petroleum Geologists, Memoir 38, p. 1-33.

Mathews, W.H.
1947: Geology and coal resources of the Carbon Creek-Mount Bickford map-area. British Columbia Department of Mines, Bulletin 24.

McConnell, R.G.

1893: On a portion of the District of Athabasca comprising the country between Peace River and Athabasca River. Geological Survey of Canada, Annual Report 1890-1891, v. 5, Part D.

1896: Report on an exploration of the Finlay and Ominica rivers. Geological Survey of Canada, Annual Report, n. ser., v. 7, 1894, p. 5-40c.

McKenzie, N.D.

1955: Coal reserves of the Hasler Creek–Pine River area, British Columbia. British Columbia Department of Mines, Bulletin 36.

McLean, J.R.

1976: Cadomin Formation: eastern limit and depositional environment. *In* Current Research, Part B, Geological Survey of Canada, Paper 76-1B, p. 323-327.

1977: The Cadomin Formation, stratigraphy, sedimentology and tectonic implications. Bulletin of Canadian Petroleum Geology, v. 25, p. 792-827.

1982: Lithostratigraphy of the Lower Cretaceous coal-bearing sequence, Foothills of Alberta. Geological Survey of Canada, Paper 80-29.

McLean, J.R. and Wall, J.H.

1981: The Early Cretaceous Moosebar Sea in Alberta. Bulletin of Canadian Petroleum Geology, v. 29, no. 3, p. 334-377.

McLearn, F.H.

1918: Peace River section, Alberta. Geological Survey of Canada, Summary Report, 1917, Part C, p. 14-21.

1923: Peace River Canyon coal area, British Columbia. Geological Survey of Canada, Summary Report, 1922, Part B, p. 1-46.

1931: Environment of dinosaur tracks in the Peace River Canyon. Geological Society of America, Bulletin, v. 42, p. 362.

1932: Problems of the Lower Cretaceous of the Canadian interior. Royal Society of Canada, Transactions, Third series, v. 26, sec. 4, p. 157-175.

1940: Notes on the geography and geology of the Peace River Foothills. Royal Society of Canada, Transactions, Third Series, v. 34, p. 63-74.

1944a: Revision of the Lower Cretaceous of the western interior of Canada. Geological Survey of Canada, Paper 44-17, 2nd edition.

1944b: Revision of the palaeogeography of the Lower Cretaceous of the western interior of Canada. Geological Survey of Canada, Paper 44-32.

McLearn, F.H. and Irish, E.J.W.

1944: Some coal deposits of the Peace River Foothills, British Columbia. Geological Survey of Canada, Paper 44-15.

McLearn, F.H. and Kindle, E.D.

1950: Geology of northeastern British Columbia. Geological Survey of Canada, Memoir 259.

Mellon, G.B.

1967: Stratigraphy and petrology of the Lower Cretaceous Blairmore and Mannville groups, Alberta Foothills and Plains. Research Council of Alberta, Bulletin 21, 270 p.

Oppelt, H.P.

1986: Stratigraphy and character of the Bluesky Formation (94 A, B, H, G; 93 I, O, P). *In* Geological Fieldwork, 1985; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1986-1, p. 161-166.

Pemberton, S.G. and Frey, R.W.

1983: Biogenic structures in Upper Cretaceous outcrops and cores. *In* Field Trip Guidebook No. 8, The Mesozoic of Middle North America, Canadian Society of Petroleum Geologists Conference, 1983, Calgary, Alberta.

Pugh, D.C.

1960: The subsurface Gething and Bluesky formations of northeastern British Columbia. Geological Survey of Canada, Paper 60-1.

Reineck, H.E. and Singh, I.B.

1973: Depositional Sedimentary Environments with Reference to Terrigenous Clastics. Springer-Verlag, New York, Heidelberg, Berlin, 439 p.

Riegel, W.
1977: The scope of coal geology. Contributions to Geology, University of Wyoming, v. 15, no. 2, p. 73-78.

Rudkin, R.A.
1964: Lower Cretaceous. *In* Geological History of Western Canada, Chapter II; Alberta Society of Petroleum Geologists, Calgary, Alberta.

Rust, B.R.
1979: Coarse alluvial deposits. *In* Facies Models, R.G. Walker (ed.); Geoscience Canada, Reprint Series 1, p. 9-21.

Schultheis, N.H. and Mountjoy, E.W.
1978: Cadomin conglomerate of western Alberta—a result of Early Cretaceous uplift of the Main Ranges. Bulletin of Canadian Petroleum Geology, v. 26, p. 297-342.

Selwyn, A.R.C.
1877: Report on exploration in British Columbia in 1875. Geological Survey of Canada, Report of Progress 1875-1876, p. 28-86.

Smith, D.G., Zorn, C.E., and Sneider, R.M.
1984: The paleogeography of the Lower Cretaceous of western Alberta and northeastern British Columbia in and adjacent to the Deep Basin of the Elmworth area. *In* Elmworth—Case Study of a Deep Basin Gas Field, J.A. Masters (ed.); American Association of Petroleum Geologists, Memoir 38, p. 79-114.

Smith, R.
1984: Gas reserves and production performance of the Elmworth/Wapiti area of the Deep Basin. *In* Elmworth—Case study of a Deep Basin Gas Field, J.A. Masters (ed.); American Association of Petroleum Geologists, Memoir 38, p. 153-172.

Spears, D.A. and Duff, P.McL.D.
1981: Mineralogy and geochemistry of some tonsteins and K-bentonites in the Peace River Coalfield, British Columbia. Geological Association of Canada, Annual Meeting, Program with Abstracts, May 1981, p. A-53.

1984: Kaolinite and mixed-layer illite-smectite in Lower Cretaceous bentonites from the Peace River Coalfield, British Columbia. Canadian Journal of Earth Sciences, v. 21, p. 465-476.

Spivak, J.
1944: Geology and coal deposits of Hasler Creek area, British Columbia. Geological Survey of Canada, Paper 44-7.

Stach, E., Taylor, G.H., Mackowsky, M.T., Chandra, D., Teichmüller, M., and Teichmüller, R.
1982: Coal Petrology. Gebruder Borntreger, Berlin-Stuttgart.

Staub, J.R. and Cohen, A.D.
1979: The Snuggedy swamp of South Carolina: a back-barrier estuarine coal-forming environment. Journal of Sedimentary Petrology, v. 49, no. 1, p. 133-144.

Stelck, C.R., Wall, J.H., Bahan, W.G., and Martin, L.J.
1956: Middle Albian Foraminifera from Athabasca and Peace River drainage areas of Western Canada. Research Council of Alberta, Report 75, 60 p.

Stott, D.F.
1960: Cretaceous rocks between Smoky and Pine rivers, Rocky Mountain Foothills, Alberta and British Columbia. Geological Survey of Canada, Paper 60-16.

1961: Dawson Creek map-area, British Columbia. Geological Survey of Canada, Paper 61-10.

1962: Cretaceous rocks of Peace River Foothills. Edmonton Geological Society; Fourth Annual Field Trip, Guidebook, p. 22-45.

1963: Stratigraphy of the Lower Cretaceous Fort St. John Group, Gething and Cadomin formations, Foothills of northern Alberta and British Columbia. Geological Survey of Canada, Paper 62-39.

1967: The Fernie and Minnes strata north of Peace River, Foothills of northeastern British Columbia. Geological Survey of Canada, Paper 67-19.

1968: Lower Cretaceous Bullhead and Fort St. John groups, between Smoky and Peace rivers, Rocky Mountain Foothills, Alberta and British Columbia. Geological Survey of Canada, Bulletin 152.

1969: The Gething Formation at Peace River Canyon, British Columbia. Geological Survey of Canada, Paper 68-28.

1970: Jurassic and Cretaceous rocks of Pine River region, British Columbia. Edmonton Geological Society Field Conference Guide Book, Peace River Pine Pass Yellowhead, 1970, p. 58-83.

1972a: Cretaceous stratigraphy, northeastern British Columbia. *In* Proceedings of the First Geological Conference on Western Canadian Coal, G.B. Mellon, J.W. Kramers, and E.J. Seagel (eds.); Research Council of Alberta, Information series no. 60, p. 137-150.

1972b: The Cretaceous Gething delta, northeastern British Columbia. *In* Proceedings of the First Geological Conference on Western Canadian Coal, G.B. Mellon, J.W. Kramers, and E.J. Seagel (eds.); Research Council of Alberta, Information series no. 60, p. 151-163.

1973: Lower Cretaceous Bullhead Group between Bullmoose Mountain and Tetsa River, Rocky Mountain Foothills, northeastern British Columbia. Geological Survey of Canada, Bulletin 219.

1974: Lower Cretaceous coal measures of the Foothills of west-central Alberta and northeastern British Columbia. Canadian Institute of Mining and Metallurgy, Bulletin, v. 67, no. 749, p. 87-100.

1975: The Cretaceous System in northeastern British Columbia. *In* The Cretaceous System of the Western Interior of North America, W.G.E. Caldwell (ed.); Geological Association of Canada, Special Paper 13, p. 441-467.

1981: Bickford and Gorman Creek, two new formations of the Jurassic-Cretaceous Minnes Group, Alberta and British Columbia. *In* Current Research, Part B, Geological Survey of Canada, Paper 81-1B, p. 1-9.

1983: Late Jurassic-Early Cretaceous foredeeps of northeastern British Columbia. Royal Society of Canada, Transactions; Series IV, v. XXI, p. 143-153.

1984: Cretaceous sequences of the Foothills of the Canadian Rocky Mountains. *In* The Mesozoic of Middle North America, D.F. Stott and D.J. Glass (eds.); Canadian Society of Petroleum Geologists, Memoir 9, 1984, p. 85-107.

Stott, D.F. and Gibson, D.W.
1980: Minnes coal, northeastern British Columbia. *In* Current Research, Part C, Geological Survey of Canada, Paper 80-1C, p. 135-137.

Taylor, D.R. and Walker, R.G.
1984: Depositional environments and paleogeography in the Albian Moosebar Formation and adjacent fluvial Gladstone and Beaver Mines formations, Alberta. Canadian Journal of Earth Sciences, v. 21, no. 6, p. 698-714.

Varley, C.J.
1984: The Cadomin Formation: a model for the deep basin type gas trapping mechanism. *In* The Mesozoic of Middle North America, D.F. Stott and D.J. Glass (eds.); Canadian Society of Petroleum Geologists, Memoir 9, p. 471-484.

Wallis, G.R. and Jordan, G.R.
1974: The stratigraphy and structure of the Lower Cretaceous Gething Formation of the Sukunka River coal deposit in British Columbia. Canadian Institute of Mining and Metallurgy, Bulletin, v. 67, no. 743, p. 142-147.

Weimer, R.J.
1977: Stratigraphy and tectonics of western coals. *In* Geology of Rocky Mountain Coal. Proceedings of the 1976 Symposium, Resource Series 1, D.K. Murray (ed.); Colorado Geological Survey, Department of Natural Resources, State of Colorado, p. 9-28.

Welte, D.H., Schaefer, R.G., Stoessinger, W., and Radke, M.
1984: Gas generation and migration in the Deep Basin of Western Canada. *In* Elmworth—Case Study of a Deep Basin Gas Field, J.A. Masters (ed.); American Association of Petroleum Geologists, Memoir 38, p. 35-47.

White, G.V.
1983: The Bluesky—a stratigraphic marker in northeastern British Columbia (93 I, O, P). *In* Geological Fieldwork 1982; British Columbia Ministry of Energy, Mines and Petroleum Resources, Paper 1983-1, p. 85-87.

Williams, C.
1984: The Bluesky Formation of northeastern British Columbia: depositional history and stratigraphy. B.Sc. thesis, University of Calgary, 32 p.

Williams, G.D. and Stelck, C.R.
1975: Speculations on the Cretaceous paleogeography of North America. *In* The Cretaceous System in the Western Interior of North America, W.G.E. Caldwell (ed.); Geological Association of Canada, Special Paper no. 13, p. 1-20.

Wyman, R.E.
1984: Gas resources in Elmworth coal seams. *In* Elmworth—Case Study of a Deep Basin Gas Field, J.A. Masters (ed.); American Association of Petroleum Geologists, Memoir 38, p. 173-187.

APPENDIX 1

SECTION AND WELL DATA

A. FIELD SECTIONS

(Thicknesses in metres)

Name	Location NTS	Location UTM	Gething Formation	Chamberlain Member	Bullmoose Member	Gaylard Member	Gething/ Moosebar Contact	Gething/ Cadomin Contact
Holtslander Creek 79-1	93 I/9	675800E 6043400N	83.7	–	–	–	Yes	Yes
Five Cabin Creek 79-2	93 I/14	626900E 6083200N	152.4	?	?	?	Yes	Yes
Dokken Creek 79-3	93 I/10	650400E 6063500N	128.0	–	–	–	Yes	Yes
Red Deer Adit Rd. 79-4	93 I/9	662200E 6054800N	38.8 +	–	–	–	No	Yes
Cleveland Creek 79-5	93 O/9	541000E 6161600N	45.3 +	–	–	43.3 +	No	Yes
Type section 79-6 (Bennett Dam)	94 B/1	548300E 6207300N	506.1 +	–	–	506.1 +	No	Yes
Aylard Creek 79-7	93 O/16	548880E 6203400N	168.6 +	–	–	168.6 +	Yes	No
Bullmoose Mountain 80-1	93 P/3	596300E 6116500N	297.1	76.6	61.3	158.8	Yes	Yes
Mt. Reesor 80-2	93 P/3	600300E 6102600N	288.0	?	?	?	Yes	Yes
Pink Mountain 81-1	94 G/2	506500E 6326600N	267.6	–	–	267.6	Yes	Yes
*Grande Cache Rail 82-1	83 E/14	361700E 5985000N	86.8 +	–	–	–	No	Yes
*Grande Cache Lumber 82-2	83 E/14	360600E 5983700N	25.2 +	–	–	–	Yes	No
Mt. Torrens 82-3	83 L/5	305420E 6019960N	51.4	–	–	–	Yes	Yes
Mt. Torrens (south) 82-4	83 L/5	305860E 6019500N	61.4	–	–	–	Yes	Yes
Dumbgoat Mtn. (F) 82-5	93 I/8	664800E 6038200N	61.3	–	–	–	Yes	Yes
Dumbgoat Mtn. (H) 82-6	93 I/8	665160E 603600N	65.0	–	–	–	Yes	Yes
*Gustavs Flats 82-7	83 E/14	357200E 5978600N	99.6	–	–	–	Yes	Yes
Mt. Rochfort 82-8	93 O/15	509000E 619880N	1100.0 +	–	–	1100.0 +	No	Yes

*Thickness of laterally equivalent Gladstone Formation

B. COAL EXPLORATION BOREHOLES

(Thicknesses in metres)

Name	Location		Gething Formation		Chamberlain Member		Bullmoose Member		Gaylard Member		Gething/ Moosebar Contact	Gething/ Cadomin Contact
	NTS	UTM	Apparent	True	Apparent	True	Apparent	True	Apparent	True		
Utah WCC 78-2	93 O/15	507280E 6204620N	144.8 +	144.8 +	–	–	–	–	144.8 +	144.8 +	No	No
Utah WCC 80-5	93 O/15	507880E 6203060N	221.3 +	221.3 +	–	–	–	–	221.3 +	221.3 +	No	No
Utah WCC 78-1	93 O/15	507160E 620[illegible]0N	210.6 +	210.6 +	–	–	–	–	210.6 +	210.6 +	No	No
Utah WCC 82-8	93 O/15	508040E 6200520N	432.0 +	432.0 +	–	–	–	–	423.0 +	423.0 +	No	No
Utah BRI Dowling 78-5	93 O/16	539200E 6197000N	252.6	227.0 +	–	–	–	–	252.6 +	227.0 +	No	No
Utah BRI Dowling 78-4	93 O/16	540900E 6201600N	132.3 +	126.5 +	–	–	–	–	132.3 +	126.5 +	Yes	No
Denison HHD 80-01	94 A/4	579000E 6220300N	158.1	158.1	–	–	–	–	158.1	158.1	Yes	Yes
Denison PD 80-01	94 A/3	622500E 6215000N	122.8	122.8	–	–	–	–	122.8	122.8	Yes	Yes
Gulf Goodrich GDR 81-06	93 O/8	548457E 6141170N	208.6 +	106.3 +	4.3	1.7	54.9	22.3	149.4 +	82.3 +	Yes	No
Gulf Goodrich GDR 80-39	93 O/8	547816E 6142463N	433.7 +	317.8 +	–	–	–	–	433.7 +	317.8 +	No	Yes
Gulf Goodrich GDR 81-08	93 O/8	549726E 6142369N	162.5 +	150.2 +	–	–	–	–	162.5 +	150.2 +	No	Yes
Pan Ocean PP H-1	93 O/9	553500E 6157000N	403.6 +	368.7 +	–	–	–	–	403.6 +	368.7 +	Yes	No
Norcen PP 79-1	93 O/9	561920E 6152120N	197.7 +	129.2 +	–	–	–	–	197.7 +	129.2 +	Yes	No
Pan Ocean PP 75-5	93 O/8	561580E 6139800N	344.7 +	341.8 +	–	–	–	–	344.7 +	341.8	No	Yes
BP 80-4	93 P/5	570750E 6129100N	92.4 +	92.2 +	–	–	–	–	92.4 +	92.2 +	No	Yes
BP 81-13	93 P/4	580250E 6122450N	258.7 +	239.5 +	–	–	24.1	23.9 +	234.6	215.6	No	Yes
BP-53	93 P/4	588170E 6120861N	352.7 +	352.7 +	96.4	96.4	76.6	76.6	179.8 +	179.8 +	Yes	No

Name	Location		Gething Formation		Chamberlain Member		Bullmoose Member		Gaylard Member		Gething/ Moosebar Contact	Gething/ Cadomin Contact
	NTS	UTM	Apparent	True	Apparent	True	Apparent	True	Apparent	True		
BP-2	93 P/4	593700E 6114900N	297.1+	297.1+	77.0	77.0	56.4	56.4	163.7+	163.7+	Yes	No
Denison QWD 74-03	93 P/3	611800E 6103800N	191.1+	191.1+	–	–	35.0+	35.0+	156.1	156.1	No	Yes
Pacific MDD 79-18	93 I/15	643792E 6075628N	108.3+	102.9+	62.68	59.2	1.6	1.6	44.0+	42.1+	Yes	No
NoPacific MDD 78-03	93 I/15	644835E 6073290N	137.4+	128.2+	62.9	60.7	2.0	1.9	72.5	65.6	Yes	Yes
Pacific MDD 77-3	93 I/15	644485E 6072158N	158.1	150.05	69.2	65.8	8.1	7.7	80.8	76.6	Yes	Yes
Pacific MDD 78-04	93 I/15	645360E 6071810N	142.5	131.2	71.5	65.8	2.9	2.7	67.9	62.7	Yes	Yes
Pacific MDD 78-07	93 I/15	644187E 6071487N	130.5	125.4	62.8	60.4	6.0	5.7	61.7	59.3	Yes	Yes
Pacific MDD 78-08	93 I/15	643792E 6075628N	131.4	123.4	66.0	61.5	6.5	6.2	58.9	55.7	Yes	Yes
Pacific BWD 76-4	93 I/10	655094E 6050667N	87.5	84.1	–	–	–	–	–	–	Yes	Yes
Denison BD 78-10	93 I/9	663480E 6054521N	91.8+	71.6+	–	–	–	–	–	–	Yes	No
Denison BD 79-08	93 I/9	663358E 6052834N	84.2+	82.4+	–	–	–	–	–	–	Yes	No
Denison BD 80-06	93 I/9	668026E 6050518N	109.0	80.5	–	–	–	–	–	–	Yes	Yes
Denison BD 78-11	93 I/9	676826E 6043528N	77.5	70.2	–	–	–	–	–	–	Yes	Yes
Denison BD 78-15	93 I/8	684343E 6037829N	60.7	35.6	–	–	–	–	–	–	Yes	Yes
Petro-Can MND 81-02	93 I/8	677588E 6017611N	55.9	53.5	–	–	–	–	–	–	Yes	Yes
Petro-Can DDH 81-04	93 I/10	649339E 6067910N	172.0+	172.0+	137.4	137.4	1.7	1.7	33.0+	33.0+	Yes	No

C. PETROLEUM EXPLORATION WELLS
(Thicknesses in metres)

Name	Location B.C. Land Survey System	(NTS)	Gething Formation		Chamberlain Member		Bullmoose Member		Gaylard Member		Gething/ Moosebar Contact	Gething/ Cadomin Contact
			Apparent	True	Apparent	True	Apparent	True	Apparent	True		
Arco Pacific Robertson	*b-71-k*	(94 B/15)	32.0	–	–	–	–	–	320.0	–	Yes	Yes
Alaska Phillips No. 1	*b-25-I*	(94 B/16)	51.0	–	–	–	–	–	51.0	–	Yes	Buick Ck.
Zephyr et al. Fireweed	*a-7-e*	(94 A/14)	29.0	–	–	–	–	–	29.0	–	Yes	Buick Ck.
Pacific Rabbit	*b-39-A*	(94 A/16)	41.0	–	–	–	–	–	41.0	–	Yes	Fernie Fm.
Westcoast et al. Coplin	6-21-84-23/W6*		120.0	–	–	–	–	–	120.0	–	Yes	Yes
Pacific et al. Pingel	13-17-81-17/W6*		147.0	–	–	–	–	–	147.0	–	Yes	Yes
Pacific Westcoast Pouce	7-30-80-13/W6*		133.0	–	–	–	–	–	133.0	–	Yes	Yes
Getty et al. Gwillim	*c-27-E*	(93 P/6)	216.0	–	23.4	–	87.2	–	105.4	–	Yes	Yes
Phillips Puggins	*c-40-L*	(93 P/7)	198.7	–	17.7(?)	–	40.0(?)	–	141.0	–	Yes	Yes
Amoco Home et al. Sundown	*a-10-A*	(93 P/10)	135.0	–	?	–	?	–	?	–	Yes	Yes
Shell Oetata	*b-48-L*	(93 P/8)	155.0	–	–	–	–	–	–	–	Yes	Yes
Union et al. Tupper	*b-25-I*	(93 P/8)	121.3	–	–	–	–	–	–	–	Yes	Yes
KM-AEG Mast	*d-80-A*	(93 P/3)	218.0	–	43.8	–	37.9	–	136.3	–	Yes	Yes
Wainoco et al. Mink	*c-94-B*	(93 P/2)	162.3	–	28.6	–	16.0	–	117.7	–	Yes	Yes
Cdn. Superior Windsor	*a-66-I*	(93 I/16)	136.0	–	10.2	–	10.8	–	115.0	–	Yes	Yes
Quasar et al. Murray	*a-89-E*	(93 I/15)	177.0	–	?	–	?	–	?	–	Yes	Yes
Texex Flatbed	*a-21-F*	(93 I/15)	137.0	–	?	–	?	–	?	–	Yes	Yes
Quasar Grizzly (KM)	*a-49-H*	(93 I/15)	160.0	–	?	–	?	–	?	–	Yes	Yes
Pacific et al. Ojay	*c-12-L*	(931/9)	100.0	–	–	–	–	–	–	–	Yes	Yes

*Western Canada Township/Range Survey System

APPENDIX 2

PALEONTOLOGY

A. MICROPALEONTOLOGY

by J.H. Wall

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
	Bullmoose Mountain, Section 80-1	
Gaylard Member, Unit 7, 246.6 m below Moosebar	No microfossils obtained.	C-89312a
Gaylard Member, Unit 23, 214.6 m below Moosebar	**Foraminifera:** *Ammodiscus rotalarius* Loeblich Tappan—two genus indeterminate—fragment of a siliceous form **Porifera:** assorted spicules (reworked?) **Seeds:** *Microcarpolithes* sp., a form genus (see McLean and Wall, 1981, Pl. 6, figs. 8, 9) **Botanical debris:** silicified(?) stem fragments **Age**. Early Cretaceous, Albian indicated. **Environment**. A marginal marine setting, such as a swamp, is suggested by the combination of seeds, botanical debris, abundant coaly and carbonaceous material, and rare foraminifers.	C-89312b
Gaylard Member, Unit 33, 187.5 m below Moosebar	**Foraminifera:** *Saccammina* sp. *Milliammina* spp.—some specimens appear to be reworked *Haplophragmoides*(?) sp.—probably reworked *Gaudyrina nanushukensis* Tappan (?)—one apparently reworked specimen *Uvigerinammina*(?) sp.—one apparently reworked specimen *Verneuilinoides*(?) sp.—one apparently reworked specimen **Bivalvia (Pelecypoda):** shell fragments **Age**. Early Cretaceous, Albian indicated. **Environment**. Marine, shallow, probably brackish water. Assemblage consists largely of apparently reworked forms, possibly transported into a marginal marine environment.	C-89312c

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
Gaylard Member, Unit 37, 168.3 m below Moosebar	**Foraminifera** (very rare): *Bathysiphon* sp.—one *Haplophragmoides* sp.—one **Note:** These two specimens were obtained after the residue was repicked. Recovery is inadequate for a definite interpretation but a possible marine influence is suggested.	C-89312d
Gaylard Member, Unit 43, 146.8 m below Moosebar	**Foraminifera:** *Reophax* sp.—one *Miliammina subelliptica* Mellon and Wall—one *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Trochammina* sp. cf. *T. umiatensis* Tappan *Lenticulina* spp.—five specimens representing at least two species *Dentalina*(?) sp.—one probably incomplete specimen of two chambers *Globulina lacrima canadensis* Mellon and Wall *G. prisca* Reuss *G.* sp. *Serovaina loetterlei* (Tappan) *Quadrimorphina albertensis* Mellon and Wall—common **Ostracoda:** *Cytheridea bonaccordensis* Loranger genus unidentified, a small subquadrate form with steep dorsal slope—one carapace and one valve **Crinoidea:** articulation plates of arms and possible calyx parts.	C-89312e
Bullmoose Member, Unit 53, 104.5 m below Moosebar	**Foraminifera:** *Ammodiscus* sp. cf. *A. rotalarius* Loeblich and Tappan—one incomplete specimen *A.* spp.—two specimens *Glomospirella* sp.—one *Reophax* sp.—one *Haplophragmoides* sp. A of Stelck and Wall, 1956 *Recurvoides* sp. *Ammobaculites wenonahae* Tappan *A.* sp. *Gaudryina tailleuri* (Tappan) *Cyclogyra* sp.—one *Lenticulina macrodisca* (Reuss) *L.* sp. *Saracenaria dutroi* Tappan—one plus two possible immature specimens *Marginulinopsis collinsi* Mellon and Wall *M.* sp. cf. *M. reiseri* Tappan—one *Vaginulinopsis* sp. cf. *V. muelleri* (Reuss) *Dentalina dettermani* Tappan	C-89312f

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
	D. spp.—partial specimens *Lagena* sp. *Globulina lacrima canadensis* Mellon and Wall *Pyrulinoides* sp.—two *Discorbis norrisi* Mellon and Wall *Conorbina* sp. B of Stelck and Wall, 1956 *Eurycheilostoma* sp. cf. *E. robinsonae* Tappan **Bivalvia (Pelecypoda):** probably two unidentified genera with total of three nepionic specimens.	
Bullmoose Member, Unit 54, 102.8 m below Moosebar	**Foraminifera:** *Saccammina* sp.—one *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites fragmentarius* Cushman *Gaudryina nanushukensis* Tappan *G. tailleuri* (Tappan) *Uvigerinammina* sp. cf. *U. athabascensis* (Mellon and Wall)—one incomplete specimen *Lenticulina bayrocki* Mellon and Wall *L. macrodisca* (Reuss) *Saracenaria* sp. cf. *S. trollopei* Mellon and Wall—one *S. valanginiana* Bartenstein and Brand *Marginulinopsis collinsi* Mellon and Wall *M. reiseri* Tappan *Vaginulinopsis* sp. cf. *V. muelleri* (Reuss) *V. schloenbachi* (Reuss) *Dentalina dettermani* Tappan *D. praecommunis* Tappan *D.* sp. cf. *D. strangulata* Reuss—one *D.* spp. *Nodosaria* sp. cf. *N. nana* Reuss—one *N.* sp.—one *Citharina* sp.—one *Globulina lacrima canadensis* Mellon and Wall *G.* sp. *Discorbis norrisi* Mellon and Wall *Conorbina* sp. B of Stelck and Wall, 1956 **Ostracoda:** genus unidentified—two carapaces **Pisces:** one tooth.	C-89312g

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
Bullmoose Member, Unit 57, 92.8 m below Moosebar	**Foraminifera:** *Hippocrepina barksdalei* (Tappan)—two *Ammodiscus crenulatus* Chamney *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites* sp. *Lenticulina bayrocki* Mellon and Wall—one *L. macrodisca* (Reuss)—one *Saracenaria grandstandensis* Tappan—one *S. projectura* Stelck and Wall *Vaginulinopsis schloenbachi* (Reuss)—one *Vaginulina* sp.—one *Dentalina dettermani* Tappan—two *D.* sp.-spp., fragments *Nodosaria* sp.—incomplete specimens *Pseudonodosaria* sp. cf. *P. kirschneri* (Tappan)—two *Globulina* sp.—two *Discorbis norrisi* Mellon and Wall *Eurycheilostoma* sp. cf. *E. robinsonae* Tappan *Patellina elliotti* Stelck and Wall—one *Quadrimorphina albertensis* Mellon and Wall.	C-89312h
Bullmoose Member, Unit 59, 87.8 m below Moosebar	**Foraminifera:** *Haplophragmoides* sp. A of Stelck and Wall, 1956 *Ammobaculites* sp., small, poorly preserved—two *Saracenaria projectura* Stelck and Wall—two *Vaginulinopsis* spp.—two specimens nodosariinid fragments cf. *Dentalina* and possibly *Nodosaria* *Globulina prisca* Reuss *G.* sp. *Discorbis norrisi* Mellon and Wall *Conorbina* sp. B of Stelck and Wall, 1956 *Quadrimorphina albertensis* Mellon and Wall—common **Note:** The following remarks apply to units 43 to 59. **Age**. Late Early Albian, *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone (Caldwell et al., 1978). **Environment**. Normal marine, moderate depth on shelf.	C-89312i
	Pink Mountain, Section 81-2	
Cadomin, Unit 10, 40.4 m above Fernie	No microfossils obtained.	C-89888
Cadomin, Unit 20, 52.4 m above Fernie	No microfossils obtained.	C-89889

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
Gaylard Member, Unit 73, 197 m above Fernie	**Foraminifera**(?): one questionable specimen, possibly an altered *Haplophragmoides*.	C-89890
Gaylard Member, Unit 86, 213 m above Fernie	No microfossils obtained.	C-89891
Gaylard Member, Unit 96, 238 m above Fernie	No microfossils obtained.	C-89892
Gaylard Member, Unit 101, 267 m above Fernie	**Foraminifera:** *Bathysiphon* sp., robust—two specimens (may not be indigenous to sample) *Hippocrepina* spp. *Ammobaculites* sp. cf. *A. fragmentarius* Cushman *Trochammina* sp.—one *Verneuilinoides*(?) sp., small—one **Age**. Cretaceous, stage indeterminate. **Environment**. Marine.	C-89893
	Peace Canyon—Bennett Dam, Section 79-6	
Cadomin, Unit 8, 23 m above base of section	No microfossils obtained. **Note**: This section is identical to Section 68-18 of D.F. Stott (see Stott, 1969, p. 12; 1973, p. 206). These samples were collected from selected units as numbered by Stott.	C-89856
Cadomin, Unit 9, 28.5 m above base of section	**Foraminifera:** one fragment of an indeterminate agglutinated form **Environment**. Uncertain, possibly brackish water but data inadequate for meaningful interpretation (much coaly material in residue).	C-898319
Cadomin, Unit 13, 43.3 m above base of section	**Foraminifera**(?): *Saccammina*(?) sp.—two **Environment**. Uncertain, possibly brackish water.	C-89857
Gaylard Member, Unit 27, 99.4 m above base of Gething	**Charophyta:** *Aclistochara* sp.—mostly as fragmentary gyrogonites *Praechara* sp.—two gyrogonites **Ostracoda:** *Metacypris* sp.—fragments **Gastropoda:** *Scalez* sp.—form genus of opercula—fragments **Foraminifera:** *Haplophragmoides* sp.—one specimen	C-89328

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
	Environment. Dominantly fresh water; the single foraminiferal specimen, if indigenous, might indicate a tendency toward brackish water.	
Gaylard Member, Unit 38, 116.3 m above base of Gething	One indeterminate siliceous entity, probably organic.	C-89329
Gaylard Member, Unit 41, 119.9 m above base of Gething	One poorly preserved foraminifer, probably calcareous (reworked?) One indeterminate siliceous organism **Environment**. Indeterminate.	C-89330
Gaylard Member, Unit 80, 216.3 m above base of Gething	**Foraminifera:** *Saccammina* sp.—one (?)siliceous form, indeterminate Unknown siliceous organisms, some of which may be primitive foraminifers **Environment**. Uncertain, weakly brackish to possibly fresh water is indicated.	C-89349
Gaylard Member, Unit 94, 259.7 m above base of Gething	**Foraminifera:** *Saccammina* sp.—two Rare fragments of questionable forms **Environment**. Uncertain, possibly brackish water.	C-89331
Gaylard Member, Unit 104, 286.4 m above base of Gething	**Foraminifera:** *Ammodiscus*(?) sp., distorted—one *Saccammina*(?) sp. **Thecamoebians:** genus unknown—common in fine fraction **Ostracoda:** *Metacypris* sp.—fragments **Environment**. Weakly brackish to possibly fresh water.	C-89851
Gaylard Member, Unit 111, 298.2 m above base of Gething	**Foraminifera:** *Ammodiscus* sp.—one incomplete specimen *Haplophragmoides* sp.—three Indeterminate siliceous organisms, including some probable thecamoebians **Ostracoda:** *Metacypris* sp.—fragments **Environment**. Probably slightly brackish water.	C-89865

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
Gaylard Member, Unit 115, 303.4 m above base of Gething	**Foraminifera:** *Saccammina* sp. *Haplophragmoides* sp.—one *Trochammina* sp., very small—one Indeterminate siliceous organisms **Environment**. Probably slightly brackish water. **Comments**. The microfossils recovered from this set of samples from Section 79-6 are entirely inadequate for any accurate age assignment as none could be specifically identified. The nonmarine charophytes and ostracodes are allied to forms regarded as Aptian-Albian in age. Environments of deposition of most of these samples are difficult to interpret due to the general lack of fauna or the occurrence of a mixture of organisms normally associated with different environments. There does not appear to have been any development of normal marine conditions. Foraminifera that would indicate such an environment are rare and usually accompanied or eclipsed by organisms such as charophytes, thecamoebians, and unknown siliceous entities that are generally considered to be freshwater inhabitants. Some brackish water marine influence does, however, seem to be evident through parts of this sequence.	C-89852
	Utah Mines, WCC 80-5 borehole	
Gaylard Member, 37.53 m below top of borehole	**Charophyta:** *Stellatochara mundula* (Peck) *Sphaerochara* sp.-spp.—generally poorly preserved gyrogonites and probable oospore fragments **Gastropoda:** opercula fragments **Age**. Early Cretaceous, late Aptian (?)-Albian indicated. **Environment**. Fresh water.	C-97523/ 37.53
Gaylard Member, 37.68 m below top of borehole	**Charophyta:** *Stellatochara mundula* (Peck) *Sphaerochara* sp.—gyrogonites and probable oospores *Praechara*(?) sp., poorly preserved **Gastropoda:** one conch fragment and some opercula fragments **Age and environment**. As for previous sample.	C-97523/ 37.68

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Gaylard Member, 172.12 m below top of borehole	**Ostracoda:** *Candona*(?) sp., large, pyritized—one incomplete carapace genus-genera indeterminate—fragments of probably nonmarine forms **Age**. Early Cretaceous. **Environment**. Probably fresh water.	C-97523/ 172.12
	Utah Mines, WCC 82-8 borehole	
Gaylard Member, 13.9 m below top of borehole	**Ostracoda:** *Bisulcocypris* (=*Metacypris*) sp.—most are poorly preserved *Candona*(?) sp., large, poorly preserved—one **Gastropoda:** opercula fragments **Bivalvia (Pelecypoda):** one incomplete specimen **Charophyta:** one probable oospore **Age**. Early Cretaceous, late Aptian(?)-Albian indicated. **Environment**. Probably dominantly fresh water.	C-97508/ 13.90
Gaylard Member, 14.77 m below top of borehole	**Charophyta:** *Sphaerochara*(?) sp., mostly poorly preserved—common **Gastropoda:** opercula fragments **Age**. Early Cretaceous, late Aptian(?)-Albian assumed although range of charophyte is not known. **Environment**. Fresh water. **Note:** The large residue is brownish grey, silty material.	C-98460/ 14.77
Gaylard Member, 57.4 m below top of borehole	**Foraminifera:** *Saccammina* sp. *Hippocrepina* sp.-spp. *Miliammina* spp.—two specimens *Reophax* sp., small—one *Haplophragmoides* sp. *Ammobaculites* sp.-spp., probably including sp. A of McLean and Wall, 1981 *Ammotium*(?) sp. *Trochammina* sp. A of McLean and Wall, 1981 *Verneuilinoides* sp. **Age**. Early Cretaceous, Albian (Early?). **Environment**. Marine, shallow, probably inner shelf to perhaps marginal marine.	C-98459/ 57.40

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Gaylard Member, 59 m below top of borehole	**Foraminifera:** *Saccammina* sp. *Hippocrepina* sp.–spp. *Miliammina* spp. *Reophax troyeri* Tappan *Haplophragmoides* sp. *Trochammina* sp. A of McLean and Wall, 1981 *Verneuilinoides* sp. **Age and Environment**. As for previous sample. **Note:** One small clam or possible branchiopod was also obtained from the residue.	C-98458/ 59.00
Gaylard Member, 71.6 m below top of borehole	**Gastropoda:** conchs with prominent ornamentation **Age**. Early Cretaceous, late Aptian(?)-Albian assumed. **Environment**. Uncertain, possibly brackish water.	C-98457/ 71.60
Gaylard Member, 71.83 m below top of borehole	**Gastropoda:** conchs with similar prominent ornamentation as in previous sample but more weathered or etched **Bivalvia (Pelecypoda):** one juvenile specimen **Age and Environment:** As for previous sample. **Note:** Large residue is a dark grey and brown, indurated shale with some silt.	C-97508/ 71.83
Gaylard Member, 73.46 m below top of borehole	**Foraminifera:** *Ammodiscus* sp.—one *Ammobaculites* sp. A of McLean and Wall, 1981—common *A*. sp., elongate, coarse grained, rough finish—common *Trochammina* sp. A of McLean and Wall, 1981—three specimens **Gastropoda:** two conch fragments **Age**. Early Cretaceous, late Aptian(?)-Early Albian indicated. **Environment**. Marine, shallow, probably marginal and brackish as suggested by lack of faunal diversity and large populations of two species.	C-97508/ 73.46
Gaylard Member, 77.7 m below top of borehole	**Foraminifera** (sparse, poorly preserved): *Haplophragmoides* sp., small—one *Ammobaculites*(?) sp., incomplete—one *Verneuilinoides*(?) sp.—two genus indeterminate—two to three specimens	C-98456/ 77.70

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Age. Early Cretaceous. **Environment**. Marine, shallow, probably marginal and brackish water.	
Gaylard Member, 84.19 m below top of borehole	**Foraminifera** (weak development, poor preservation): *Miliammina* spp.—four to five specimens *Haplophragmoides* sp.—one *Trochammina*(?) sp.—two *Verneuilinoides*(?) sp.—one **Bivalvia (Pelecypoda):** fragments **Pisces:** partial tooth and rare bone fragments **Age**. Early Cretaceous. **Environment**. Marine, shallow, probably marginal and brackish water.	C-9845/ 84.19
Gaylard Member, 84.85 m below top of borehole	**Foraminifera:** *Miliammina sproulei* Nauss—two *M.* sp. *Reophax* or incomplete *Ammobaculites* sp., rough finish—one *Haplophragmoides* sp., poor preservation—two *Pseudobolivina* sp. *Uvigerinammina* (?) sp.—two *Verneuilinoides* spp.—three specimens *Lingulina* sp.—one **Branchiopoda(?):** *Cyzicus*(?) sp., very small—one **Gastropoda:** conch fragments **Age**. Early Cretaceous, late Aptian(?)-Early Albian assumed. **Environment**. Marine, shallow, possibly marginal marine and brackish water.	C-97508/ 84.85
Gaylard Member, 84.95 m below top of borehole	**Foraminifera** (poor preservation): *Miliammina* sp. *Haplophragmoides* sp.—three *Pseudobolivina* spp. *Verneuilinoides* sp. **Gastropoda:** small to relatively large conchs **Age**. Early Cretaceous, late Aptian(?)-Albian assumed, although ranges of components are not established. **Environment**. Marine, shallow, possibly marginal marine and brackish water.	C-98454/ 84.95

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Gaylard Member, 93.15 m below top of borehole	**Foraminifera:** *Miliammina* spp. *Reophax* spp.—may include incomplete *Ammobaculites* *Pseudobolivina* sp. *Trochammina* sp. A of McLean and Wall, 1981 *Verneuilinoides* sp. **Gastropoda:** conch fragments **Age**. Early Cretaceous, late Aptian(?)-Albian indicated. **Environment**. Marine, shallow, possibly marginal marine and brackish water.	C-97508/ 93.15
Gaylard Member, 93.95 m below top of borehole	**Ostracoda:** *Heterocypris*(?) sp.—same as reported from near top of Beaver Mines Formation in southern Alberta Foothills (Wall, *in* Mellon 1967, p. 23) genus indeterminate, elongate rectangular—one carapace and possible fragments **Branchiopoda:** *Cyzicus* sp.—three **Age.** Early Cretaceous, probably late Aptian(?)-Albian. The occurrence level of the *Heterocypris*(?) in the southern Foothills would suggest Middle Albian. However, there is not sufficient information on the distribution of this species to use it for accurate dating. Like nonmarine ostracodes in general, it probably has a fairly extensive range. **Environment.** Probably dominantly fresh to slightly brackish water.	C-98453/ 93.95
Gaylard Member, 121.2 m below top of borehole	**Ostracoda:** *Cypridea*(?) sp., small—two *Candona*(?) sp., large—fragments **Gastropoda:** conch fragments **Age**. Early Cretaceous, probably late Aptian(?)-Early Albian. **Environment**. Probably dominantly fresh water.	C-97508/ 121.2
Gaylard Member, 200.65 m below top of borehole	**Ostracoda:** unidentified fragments, possibly of *Candona* **Age**. Unknown. **Environment**. Uncertain, probably nonmarine.	C-97508/ 200.65

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Note: Part of the above borehole was sampled by both Gibson and Stott, resulting in the assignment of two sets of GSC locality numbers. Gibson has used the same locality number throughout the borehole; Stott has assigned a different locality number for each sample from the borehole.	
	Utah Mines, BRI-Dowling 78-4 borehole	
Gaylard Member, 0-0.4 m below Moosebar	**Foraminifera:** *Hippocrepina* spp. **Age.** Early Cretaceous, late Aptian(?)–Albian indicated. **Environment.** Probably brackish water.	C-72258/ 552.9-554.2
Gaylard Member, 4.09 m below Moosebar	**Foraminifera:** siliceous forms possibly referable to *Hippocrepina* **Thecamoebians:** thecamoebian B of McLean and Wall, 1981—two **Charophyta:** *Sphaerochara*(?) sp., poorly preserved, mostly as recrystallized gyrogonites **Age.** Early Cretaceous, late Aptian(?)–Albian indicated. **Environment.** Dominantly fresh to perhaps slightly brackish water.	C-72258/ 563.5
Gaylard Member, 25.56 m below Moosebar	**Foraminifera:** *Miliammina* sp. cf. *M. sproulei* Nauss *M.* sp. *Haplophragmoides* sp. *Ammotium* sp. *Verneuilinoides cummingensis* (Nauss)—abundant **Ostracoda:** indeterminate fragments **Age.** Early Cretaceous, late Aptian(?)–Albian indicated. **Environment.** Marine, shallow, probably marginal marine and brackish water.	C-7225/ 636.88
Gaylard Member, 113.01 m below Moosebar	**Gastropoda:** conical opercula—*Scalez* sp. B of McLean and Wall, 1981 **Age.** Early Cretaceous, late Aptian(?)–Albian indicated. **Environment.** Probably dominantly fresh water.	C-72258/ 956.5
	Denison Mines PD 80-01 borehole	
Gaylard Member, 1.56 m below Bluesky	No microfossils obtained. **Note:** Coal and pyrite in residue.	C-89866/ 561.7

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Norcen PP, 79-1 borehole	
Moosebar Formation, 1.46 m above base of Moosebar Formation	**Foraminifera:** *Haplophragmoides* sp. A of Stelck and Wall, 1956 *Lenticulina bayrocki* Mellon and Wall *L.* sp. cf. *L.* sp. of Stelck and Wall, 1956—one distorted specimen *L.* sp. *Saracenaria trollopei* Mellon and Wall—one *S.* sp. B of Stelck and Wall, 1956 *Marginulina* or *Dentalina* sp., incomplete—one *Globulina lacrima canadensis* Mellon and Wall *G.* sp. *Quadrimorphina albertensis* Mellon and Wall—dominant **Age**. Late Early Albian, *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone (Caldwell et al., 1978). **Environment**. Normal marine, moderate depth on shelf.	C-89309/ 66.96
Gaylard Member, 7.13 m below Moosebar	No microfossils obtained.	C-89309/ 75.55
Gaylard Member, 61.2-64.1 m below Moosebar	No microfossils obtained.	C-89309/ 129.62-132.52
Gaylard Member, 92.68 m below Moosebar	No microfossils obtained.	C-89309/ 161.1
Gaylard Member, 110.28 m below Moosebar	No microfossils obtained.	C-89309/ 178.7
Gaylard Member, 119.18 m below Moosebar	**Charophyta:** genus indeterminate—crushed and fragmentary gyrogonites, and probable oospore fragments **Age.** Indeterminate. **Environment**. Probably fresh water.	C-89309/ 187.6
Gaylard Member, 147.44-147.78 m below Moosebar	No microfossils obtained.	C-89309/ 215.86-216.2
Gaylard Member, 172.78 m below Moosebar	No microfossils obtained.	C-89309/ 241.2
Gaylard Member, 182.88 m below Moosebar	No microfossils obtained. Coal and carbonaceous material in residue (repicked).	C-89309/ 251.3

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	BP 80-4 borehole	
Gaylard Member, 23.78 m below top of borehole	**Ostracoda:** *Metacypris* sp., incomplete specimens *Cypridea* sp., incomplete specimens **Bivalvia (Pelecypoda):** genera unidentified—fragmentary material **Age**. Indeterminate, probably Aptian to Early Albian. **Environment**. Dominantly fresh water as indicated by the ostracode identifications.	C-97524
	BP 53 borehole	
Chamberlain Member, 27.21 m below Moosebar	No microfossils obtained.	C-72261/ 65.96
Chamberlain Member, 45.85 m below Moosebar	No microfossils obtained.	C-72261/ 84.6
Chamberlain Member, 77.15 m below Moosebar	**Foraminifera:** *Saccammina* sp., small—one *Haplophragmoides* sp. A of Stelck and Wall, 1956—dominant *Ammobaculites* sp.—one *Ammobaculites*(?) sp. (incomplete) or *Reophax* sp.—one *Uvigerinammina*(?) sp., poorly preserved—one *Conorbina* sp. B of Stelck and Wall, 1956—two	C-72261/ 115.9
Bullmoose Member, 106.96 m below Moosebar	**Foraminifera:** *Haplophragmoides* sp.—eight *Globulina* spp., mostly distorted or incomplete—five *Conorbina* sp. B of Stelck and Wall—three to four *Quadrimorphina albertensis* Mellon and Wall, small—ten **Ostracoda:** genus unidentified—one specimen	C-72261/ 145.71
Bullmoose Member, 110.37 m below Moosebar	**Foraminifera:** *Bathysiphon* sp.—one *Hippocrepina* sp. cf. *H. barksdalei* (Tappan)—one *Haplophragmoides* sp. *Ammobaculites* sp. *Trochammina* sp. *Lenticulina* sp. aff. *L.* sp. of Stelck and Wall, 1956—two possible juvenile specimens *Saracenaria trollopei* Mellon and Wall—one *Vaginulinopsis* sp., small—one *Globulina prisca* Reuss—two *G.* sp. nodosariacean fragments	C-72261/ 149.12

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Conorbina sp. A of Stelck and Wall, 1956 *C.* sp. B of Stelck and Wall, 1956 *Quadrimorphina albertensis* Mellon and Wall—dominant	
	Diatomacea: Morphotype A-4 of Wall, 1975 (from Clearwater Formation)—two Unidentified form—two	
Bullmoose Member, 120.47 m below Moosebar	**Foraminifera:** *Bathysiphon* sp.—one *Hippocrepina barksdalei* (Tappan)—one *Haplophragmoides* sp. A of Stelck and Wall, 1956 *Ammobaculites* sp. cf. *A. fragmentarius* Cushman *Gaudryina tailleuri* (Tappan) *Uvigerinammina* sp. cf. *U. athabascensis* (Mellon and Wall)—one *Lenticulina* spp.—two specimens *Marginulinopsis* sp. cf. *M. collinsi* Mellon and Wall—two *Nodosaria* sp.—detached single chambers *Globulina prisca* Reuss—one *Oolina*(?) sp.—one nodosariacean fragments—genera indeterminate *Conobina* sp. B of Stelck and Wall, 1956—one *Quadrimorphina albertensis* Mellon and Wall—small specimens	C-72261/ 159.22
Bullmoose Member, 138.41 m below Moosebar	**Foraminifera:** *Bathysiphon* sp.—one *Hippocrepina* sp.—two *Miliammina* sp., small, thin—one *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites fragmentarius* Cushman *Pseudobolivina* sp. cf. *P. rayi* (Tappan)—one *Gaudryina nanushukensis* Tappan—represented entirely by triserial forms published later by Stelck and Wall, 1956, as *Verneuilina porta*, now regarded as synonym *G. tailleuri* (Tappan) *Uvigerinammina*(?) sp., incomplete—one *Lenticulina* sp., small—one *Saracenaria valanginiana* Bartenstein and Brand *S.* sp. A of Stelck and Wall, 1956—one, possibly two, specimens *Marginulinopsis collinsi* Mellon and Wall—one adult and two to three possible immature specimens *Marginulina* sp. cf. *M. planiuscula* (Reuss)—one *Vaginulinopsis* spp. *Dentalina dettermani* Tappan *D. strangulata* Reuss *Pseudonodosaria* sp. cf. *P. kirschneri* (Tappan)	C-72261/ 177.16

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Conorbina sp. B of Stelck and Wall, 1956 *Serovaina loetterlei* (Tappan) *Quadrimorphina albertensis* Mellon and Wall **Ostracoda:** genus indeterminate, small subquadrate form with caudal extension—one **Bivalvia (Pelecypoda):** shell fragments.	
Bullmoose Member, 141.1 m below Moosebar	**Foraminifera** (much reduced fauna): *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites* sp. *Gaudryina tailleuri* (Tappan) *Conorbina*(?) sp., poorly preserved—two to three **Note:** Much glauconite observed in residue.	C-72261/ 179.85
Bullmoose Member, 170.94 m below Moosebar	**Foraminifera:** *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* spp. *Recurvoides* sp., small—one *Ammobaculites fragmentarius* Cushman *A.* sp. *Gaudryina nanushukensis* Tappan—two *G. tailleuri* (Tappan)—one *Saracenaria projectura* Stelck and Wall—one *S. trollopei* Mellon and Wall *Marginulina planiuscula* (Reuss) *Dentalina dettermani* Tappan *D. praecommunis* Tappan—one incomplete specimen and possible fragments *D.* sp. cf. *D. strangulata* Reuss nodosariinid single chambers *Globulina lacrima canadensis* Mellon and Wall—one, possibly, two specimens *G.* sp.—two *Conorbina* sp. B of Stelck and Wall, 1956 *Eurycheilostoma* sp. cf. *E. robinsonae* Tappan **Bivalvia (Pelecypoda):** *Inoceramus* sp.—presence of shell layer indicated by clusters of aragonite.	C-72261/ 209.69

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Gaylard Member, 188.75 m below Moosebar	**Foraminifera:** *Bathysiphon* sp.—one *Hippocrepina barksdalei* (Tappan)—one *Ammodiscus crenulatus* Chamney *Haplophragmoides linki* Nauss—one, possibly two, specimens *H.* sp. A of Stelck and Wall, 1956 *H.* spp. *Recurvoides* sp., small *Ammobaculites* sp. *Pseudobolivina* sp.—one *Trochammina stelcki* Chamney *T.* sp. *Gaudryina nanushukensis* Tappan—one *Lenticulina* spp.—three specimens *Vaginulina* sp.—one *Dentalina*(?) sp., incomplete—two nodosariinid single chambers *Globulina lacrima canadensis* Mellon and Wall *G.* sp. *Eoguttulina* sp.—one *Serovaina loetterlei* (Tappan)—rare *Quadrimorphina albertensis* Mellon and Wall **Ostracoda:** *Cytheridea bonaccordensis* Loranger—one complete and one probable damaged carapace *Quadrimorphina albertensis* Mellon and Wall **Bivalvia (Pelecypoda):** shell fragments, including a partial dentition unit **Note**: The following remarks apply to the samples numbered C-72261, located between 115.90 and 227.5 m in the BP Sukunka River No. 53 borehole. **Age**. Late Early Albian, *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone (Caldwell et al., 1978). **Environment**. Normal marine, moderate depth on shelf.	C-72261/ 227.5
Gaylard Member, 279.75 m below Moosebar	No microfossils obtained.	C-72261/ 318.95
	BP 2 borehole	
Chamberlain Member, 25.83 m below Moosebar	No microfossils obtained.	C-72260/ 399.55
Chamberlain Member, 28.75 m below Moosebar	No microfossils obtained.	C-72260/ 402.47
Chamberlain Member, 35.22 m below Moosebar	No microfossils obtained.	C-72260/ 408.94

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Bullmoose Member, 89.48 m below Moosebar	**Foraminifera:** *Bathysiphon* sp.—one *Reophax* sp.—two *Haplophragmoides* sp. A of Stelck and Wall, 1956 *Ammobaculites fragmentarius* Cushman *Gaudryina tailleuri* (Tappan) *Uvigerinammina* sp. cf. *U. athabascensis* (Mellon and Wall)—one *Saracenaria projectura* Stelck and Wall *S.* sp. A of Stelck and Wall, 1956 *Marginulinopsis* sp. cf. *M. reiseri* Tappan—one *Vaginulinopsis schloenbachi* (Reuss)—one *V.* sp. *Dentalina dettermani* Tappan *D.* spp.—fragments *Discorbis norrisi* Mellon and Wall—common *Conorbina* sp. B of Stelck and Wall, 1956—common *Quadrimorphina albertensis* Mellon and Wall—common.	C-72260/ 463.2
Bullmoose Member, 90.79 m below Moosebar	**Foraminifera:** *Haplophragmoides* sp. A of Stelck and Wall, 1956 *Ammobaculites fragmentarius* Cushman *Gaudryina tailleuri* (Tappan)—one *Saracenaria projectura* Stelck and Wall—one *Dentalina dettermani* Tappan nodosariinid chambers *Globulina lacrima canadensis* Mellon and Wall *G. prisca* Reuss *Quadrimorphina albertensis* Mellon and Wall—common and dominant.	C-72260/ 464.51
Bullmoose Member, 100.79 m below Moosebar	**Foraminifera:** *Bathysiphon* sp.—one *Ammodiscus crenulatus* Chamney *Reophax* sp. *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites fragmentarius* Cushman *Gaudryina tailleuri* (Tappan) *Uvigerinammina athabascensis* (Mellon and Wall)—one *Lenticulina* sp., small—one *Saracenaria* sp. cf. *S. dutroi* Tappan—two *S.* sp. aff. *S. trollopei* Mellon and Wall—one terminal portion *Vaginulinopsis* spp. *Vaginulina* sp., small—one *Dentalina* sp. cf. *D. strangulata* Reuss—one *D.* spp. nodosariacean fragments *Globulina lacrima canadensis* Mellon and Wall *Eurycheilostoma* sp. cf. *E. robinsonae* Tappan *Serovaina loetterlei* (Tappan) *Patellina elliotti* Stelck and Wall—two *Quadrimorphina albertensis* Mellon and Wall.	C-72260/ 474.51

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Bullmoose Member, 106.78 m below Moosebar	**Foraminifera:** *Bathysiphon* sp. *Saccammina* sp.—two *Ammodiscus rotalarius* Loeblich and Tappan *Reophax* sp.—two *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites fragmentarius* Cushman *Uvigerinammina athabascensis* (Mellon and Wall) *Lenticulina* spp., small *Saracenaria* sp.—two *Marginulinopsis* sp. cf. *M. collinsi* Mellon and Wall—two possibly immature specimens *M. reiseri* Tappan—one *Marginulina planiuscula* (Reuss)—one *Vaginulinopsis schloenbachi* (Reuss)—one *Frondicularia* sp.—one *Dentalina dettermani* Tappan *Globulina lacrima canadensis* Mellon and Wall *Discorbis norrisi* Mellon and Wall *Conorbina* sp. B of Stelck and Wall, 1956 *Eurycheilostoma* sp. cf. *E. robinsonae* Tappan *Serovaina loetterlei* (Tappan) *Patellina elliotti* Stelck and Wall **Ostracoda:** genus unidentified—two carapaces **Bivalvia (Pelecypoda):** genus unidentified, unornamented—one complete nepionic specimen genus unidentified, costate—one fragment **Diatomacea:** genus unidentified	C-72260/ 480.5
Bullmoose Member, 107.28 m below Moosebar	**Foraminifera:** *Hippocrepina*(?) sp.—one *A. rotalarius* Loeblich and Tappan—two *Miliammina* sp.—one *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Recurvoides* sp. *Ammobaculites fragmentarius* Cushman *Gaudryina tailleuri* (Tappan) *Uvigerinammina athabascensis* (Mellon and Wall) *Lenticulina* sp.—two *Saracenaria trollopei* Mellon and Wall—one *S.* sp. cf. *S. trollopei* Mellon and Wall—one *S.* sp., small—one *Marginulinopsis collinsi* Mellon and Wall—two *Vaginulina* sp., incomplete—one *Dentalina dettermani* Tappan *D.* spp.—fragments	C-72260/ 481

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Globulina lacrima canadensis Mellon and Wall *Discorbis norrisi* Mellon and Wall *Conorbina* sp. B of Stelck and Wall, 1956.	
Bullmoose Member, 109.51 m below Moosebar	**Foraminifera:** *Bathysiphon* sp.—one *Hippocrepina*(?) sp.—one *Ammodiscus crenulatus* Chamney—two *Miliammina* sp. cf. *M. sproulei* Nauss *Reophax* sp., incomplete—one *Haplophragmoides* sp. A of Stelck and Wall, 1956 *Recurvoides* sp. *Ammobaculites fragmentarius* Cushman *Pseudobolivina* sp.—one *Gaudryina tailleuri* (Tappan) *Lenticulina macrodisca* (Reuss) *L.* sp. *Saracenaria valanginiana* Bartenstein and Brand *Marginulinopsis collinsi* Mellon and Wall *Vaginulinopsis* sp., costate—one *Dentalina* spp.—fragments *Globulina* sp.—one *Discorbis norrisi* Mellon and Wall *Conorbina* sp. B of Stelck and Wall, 1956 *Eurycheilostoma* sp.—one *Quadrimorphina albertensis* Mellon and Wall(?), poorly preserved—two.	C-72260/ 483.23
Bullmoose Member, 128.62 m below Moosebar	**Foraminifera:** *Ammodiscus crenulatus* Chamney *A. rotalarius*, incomplete—one *Reophax* sp. *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites fragmentarius* Cushman *Gaudryina tailleuri* (Tappan)—one *Lenticulina bayrocki* Mellon and Wall—one *L.* spp. *Saracenaria dutroi* Tappan—one *S. projectura* Stelck and Wall—two *S.* sp. A of Stelck and Wall, 1956—one *S.* sp. B of Stelck and Wall, 1956—two *Marginulinopsis collinsi* Mellon and Wall *M. reiseri* Tappan—one *Vaginulinopsis schloenbachi* (Reuss) *V.* spp. *Vaginulina* sp.—one *Dentalina dettermani* Tappan *D.* spp.—incomplete specimens *Nodosaria* sp., finely striate, incomplete—one *Globulina lacrima canadensis* Mellon and Wall	C-72260/ 502.34

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Discorbis norrisi Mellon and Wall *Conorbina* sp. B of Stelck and Wall, 1956 *Eurycheilostoma* sp. cf. *E. robinsonae* Tappan *Quadrimorphina albertensis* Mellon and Wall	
Gaylard Member, 144.58 m below Moosebar	**Foraminifera:** *Saccammina* spp. *Ammodiscus crenulatus* Chamney, poorly preserved—two *Reophax troyeri* Tappan—one *R.* sp. *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites* sp.—one *Pseudobolivina* sp.—one *Trochammina* sp. cf. *T. umiatensis* Tappan—one *Gaudryina nanushukensis* Tappan—one *Lenticulina* sp. *Saracenaria* sp.—one *Marginulinopsis* sp. cf. *M. collinsi* Mellon and Wall—two possibly immature specimens *Dentalina* sp. cf. *D. strangulata* Reuss *Globulina lacrima canadensis* Mellon and Wall *G. prisca* Reuss *Eoguttulina* sp. *Quadrimorphina albertensis* Mellon and Wall **Ostracoda:** genus indeterminate—two incomplete specimens **Note:** The following remarks apply to the preceding samples between 463.2 and 518.3 m in the BP Sukunka River No. 2 borehole. **Age**. Late Early Albian, *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone (Caldwell et al., 1978). **Environment**. Normal marine, moderate depth on shelf.	C-72260/ 518.3
Gaylard Member, 158.76 m below Moosebar	**Foraminifera** (rare): *Bathysiphon*(?) sp.—two indeterminate siliceous forms, may not be foraminiferal—two **Porifera:** assorted spicules (may not be in situ) **Age**. Indeterminate. **Environment**. Uncertain, possibly a marine influence but there is insufficient evidence for a definitive interpretation.	C-72260/ 532.48
Gaylard Member, 174.98-175.16 m below Moosebar	No microfossils obtained.	C-72260/ 548.7-548.88

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Gaylard Member, 180.28 m below Moosebar	**Charophyta:** *Praechara* sp. *Sphaerochara* sp. **Ostracoda:** *Limnocypridea*(?) sp.—one incomplete carapace **Age**. Early Cretaceous, Aptian-Albian. Range data for the charophytes are inadequate for more refined age determination. **Environment**. Probably fresh water.	C-72260/ 554
Gaylard Member, 217.73 m below Moosebar	One unidentified arenaceous foraminifer recovered.	C-72260/ 591.45
Gaylard Member, 242.58 m below Moosebar	**Foraminifera** (very rare): *Ammodiscus* sp.—one indeterminate arenaceous entity, may not be foraminiferal—one **Porifera:** assorted spicules (may not be in situ) **Age**. Indeterminate. **Environment**. Uncertain, possibly a marine influence but fauna unsuitable for definitive interpretation.	C-72260/ 616.3
Gaylard Member, 272.58 m below Moosebar	Traces of ostracode and other shell fragments **Environment**. Dominantly fresh water on basis of fragmentary microfaunal evidence, supported by presence of coal and carbonaceous material.	C-72260/ 646.3
	Denison Wolverine QWD 74-03 borehole	
Gaylard Member, 83.21-84 m below top of borehole	**Foraminifera:** *Bathysiphon* sp. *Hippocrepina barksdalei* (Tappan)—one *Ammodiscus crenulatus* Chamney *Reophax* spp. *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites* sp. *Trochammina* sp. *Lenticulina* spp. *Saracenaria* sp. cf. *S. grandstandensis* Tappan—one *Marginulinopsis collinsi* Mellon and Wall—one terminal portion *Vaginulinopsis schloenbachi* (Reuss) *Vaginulina* sp.—one *Dentalina dettermani* Tappan *D. strangulata* Reuss—one *Lingulina* sp.—one *Globulina exserta* (Berthelin)—one	C-72270/ 273-275.6

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	G. prisca Reuss *Eoguttulina* sp.—one *Discorbis norrisi* Mellon and Wall, poorly preserved—one *Conorbina* sp. B of Stelck and Wall, 1956—two *Eurycheilostoma* sp. cf. *E. robinsonae* Tappan *Spirillina*(?) sp., pyritized—one *Quadrimorphina albertensis* Mellon and Wall **Bivalvia (Pelecypoda):** one nepionic specimen **Age**. Late Early Albian, *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone (Caldwell et al., 1978). **Environment**. Normal marine, moderate depth on shelf.	
Gaylard Member, 91.74 m below top of borehole	**Foraminifera:** *Hippocrepina barksdalei* (Tappan)—one *Ammodiscus crenulatus* Chamney *Reophax* spp. *Haplophragmoides* sp. A of Stelck and Wall, 1956 *Ammobaculites fragmentarius* Cushman *Saracenaria projectura* Stelck and Wall—one incomplete specimen *Vaginulinopsis* sp.—one *Globulina lacrima canadensis* Mellon and Wall—one, possibly two, small specimens *G. prisca* Reuss—one *Pyrulinoides*(?) sp.—one nodosariacean fragments *Discorbis* or *Conorbina* sp., poorly preserved—one *Spirillina*(?), pyritized—one *Quadrimorphina albertensis* Mellon and Wall, small **Age and Environment**. As for previous sample.	C-72270/ 301
Gaylard Member, 103.02 m below top of borehole	**Foraminifera** (very rare): ammodiscid, genus indeterminate—one **Porifera:** spicules (may be reworked) **Radiolaria(?):** spongodiscids(?) (may be reworked) **Seeds:** *Microcarpolithes* sp., poorly preserved—one.	C-72270/ 338
Gaylard Member, 122.37 m below top of borehole	**Bivalvia (Pelecypoda):** shell fragments only.	C-72270/ 401.5
Gaylard Member, 161.85 m below top of borehole	**Foraminifera(?):** one doubtful arenaceous foraminifer.	C-72270/ 531

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Gaylard Member, 167.03 m below top of borehole	No microfossils obtained.	C-72270/ 548
Gaylard Member, 175.56 m below top of borehole	Shell fragments obtained from residue in which coal and carbonaceous material were observed.	C-72270/ 576
Gaylard Member, 193.4 m below top of borehole	No microfossils obtained.	C-72270/ 634.5
Gaylard Member, 215.80 m below top of borehole	No microfossils obtained. **Note:** The following remarks apply to the samples from 338 to 708 m (C-72270) in the Denison Wolverine 74-03 borehole. Insufficient microfauna was recovered to permit any definitive interpretation of age and environment. Some marine influence may be associated with the assemblage at 338 m but most of these fossils could well have been recycled.	C-72270/ 708
	Pacific MDD 77-3 borehole	
Moosebar, 0.29 m above base of Moosebar Formation	**Foraminifera:** *Bathysiphon* sp. *Saccammina* sp. *Hippocrepina* sp.—two *Ammodiscus crenulatus* Chamney *A. rotalarius* Loeblich and Tappan *Glomospira corona* Cushman and Jarvis *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* spp. *Ammobaculites* sp. *Pseudobolivina* sp. *Trochammina* spp.—two specimens *Gaudryina nanushukensis* Tappan—triserial specimens *G. tailleuri* (Tappan) *Verneuilinoides* sp. *Serovaina loetterlei* (Tappan)—three **Radiolaria:** *Dictyomitra* sp., pyritized—one **Porifera:** spicules **Bivalvia (Pelecypoda):** one nepionic specimen **Age**. Late Early Albian, *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone (Caldwell et al., 1978).	C-72263/ 17.37

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Environment. Marine, moderate depth on shelf. The content of this assemblage differs from most equivalent ones encountered in this study in its dominance of agglutinated and siliceous forms and corresponding lack of calcareous components, with *Serovaina* being the only representative. If not due to the vagaries of sampling, this condition may imply some deviation from normal salinity or some other aberrant development.	
Chamberlain Member, 28.19 m below Moosebar	**Foraminifera:** *Hippocrepina barksdalei* (Tappan) *H.* sp.-spp. **Age**. Early Cretaceous, probably Albian, but the identified species by itself is inadequate for accurate age determination. **Environment**. Marine, marginal and probably brackish water. Very low-diversity arenaceous assemblages in modern environments are often associated with a brackish water regime. This interpretation is reinforced by the presence of coal particles in the residue.	C-72263/ 45.85
Chamberlain Member, 53.39 m below Moosebar	No microfossils obtained.	C-72263/ 71.05
Bullmoose Member, 69.59 m below Moosebar	No microfossils obtained.	C-72263/ 87.25
Gaylard Member, 123.09 m below Moosebar	**Foraminifera** (rare): *Reophax*(?) sp., incomplete—one *Haplophragmoides* sp.—two indeterminate form, may not be foraminiferal—two specimens **Bivalvia (Pelecypoda):** rare shell fragments **Age**. Indeterminate. **Environment**. Marine influence indicated, probably in a marginal marine and brackish water setting.	C-72263/ 140.75
Gaylard Member, 125.34 m below Moosebar	No microfossils obtained.	C-72263/ 143
	Petro-Canada 81-4 borehole	
Bullmoose Member, 286.1-286.22 m below top of borehole	Lat. 54°44′18″N, Long. 120°40′47″W Samples collected by D.A. Leckie **Foraminifera:** *Ammodiscus* sp. cf. *A. crenulatus* Chamney—two arenaceous genus indeterminate—*Trochamminoides* or *Evolutinella*—four small specimens	C-140305/ 286.1-286.22

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Quinqueloculina sp., small—one *Nodosaria*(?) sp., with some chamber constriction, wall type uncertain—two *Lingulina* spp., small—three species with total of six specimens *Globulina exserta* (Berthelin) *G.* sp.-spp. *Eoguttulina* sp., similar to *E.* sp. 32 of Magniez-Jannin 1975, Pl. 15, figures 32-34, from the Albian of France—two to three genus indeterminate, apparently calcareous and a rotaliinid—one **Branchiopoda:** *Cyzicus* sp.—one **Age**. Early Cretaceous, stage indeterminate, with Albian or Aptian indicated. Most of the components have not been identified to species level and the few that have are reported in Europe from both the Albian and older stages. **Environment**. Marine, neritic, shallow; possibly with reduced salinity as shown by the presence of the branchiopod. Almost all the assemblage is pyritized, indicating possibility of restricted circulation. Residue contains carbonized to partly pyritized wood fragments.	
Bullmoose Member, 287.22-287.82 m below top of borehole	**Foraminifera:** *Haplophragmoides* sp.—three *Pseudobolivina* sp., compressed, flaring, may be a variation of *Siphotextularia*(?) *rayi* Tappan—one *Gaudryina* sp., small, siliceous—one arenaceous genus indeterminate—a two-chambered fragment of a rectilinear form calcareous genus indeterminate—two nodosariacean fragments **Age**. Early Cretaceous, stage indeterminate. **Environment**. Marine, with a nearshore position suggested by combination of the sparse fauna and presence of much coal in residue.	C-140305/ 287.22-287.82
	Denison BD 78-11 borehole	
Bullmoose Member, 81.63 m below Moosebar	**Foraminifera** (very rare): *Miliammina* sp., small—one specimen **Age**. Indeterminate. **Environment**. Uncertain, possibly a brackish water marine influence, but the single foraminifer found after the residue was repicked is insufficient for meaningful interpretation. Coal particles were observed in residue.	C-72262/ 421

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Petro-Canada MND 81-2 borehole	
Moosebar, 49.95-50 m below top of borehole	**Foraminifera:** *Ammodiscus crenulatus* Chamney *Miliammina* sp. *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites fragmentarius* Cushman *A.* sp. *Lenticulina bayrocki* Mellon and Wall—one *L. macrodisca* (Reuss)—two *L.* spp. *Saracenaria dutroi* Tappan *S. trollopei* Mellon and Wall—one *S.* sp. A of Stelck and Wall, 1956—one *S.* sp. *Marginulinopsis collinsi* Mellon and Wall *Vaginulinopsis muelleri* (Reuss) *V.* sp. *Dentalina* spp. *Eoguttulina* sp.—one *Globulina lacrima canadensis* Mellon and Wall—one *G. prisca* Reuss *G.* spp. *Conorbina* sp. B of Stelck and Wall, 1956 *Serovaina loetterlei* (Tappan) **Ostracoda:** *Saxocythere* sp. cf. *S. tricostata* (Triebel)—one possible dimorph of species illustrated in McLean and Wall, 1981 (Pl. 8, figs. 23, 24) **Diatomacea:** indeterminate form—one **Belemnoida:** rostrum fragments **Crinoidea:** arm fragments **Bivalvia (Pelecypoda):** *Inoceramus* sp.—presence of shell layer indicated by clusters of aragonite **Age**. Late Early Albian, *Gaudryina nanushukensis* Zone, *Marginulinopsis collinsi-Verneuilinoides cummingensis* Subzone (Caldwell et al., 1978). **Environment**. Normal marine, moderate depth on shelf.	C-97522/ 49.95-50

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
Moosebar, 56.8-56.85 m below top of borehole	**Foraminifera** (less prominent): *Ammodiscus* sp.—two *Haplophragmoides* sp.-spp., poorly preserved—two specimens *Trochammina* spp.—two specimens *Lenticulina* sp., very small—one *Saracenaria* sp. cf. *S. projectura* Stelck and Wall—one *Marginulina planiuscula* (Reuss)—one *Vaginulinopsis muelleri* (Reuss)—one *Lingulina rediviva* Berthelin—one *L.* sp.—one *Globulina prisca* Reuss—one *G.* sp.-spp.—two specimens *Conorbina* sp. B of Stelck and Wall, 1956 *Serovaina loetterlei* (Tappan)—two *Patellina elliotti* Stelck and Wall—two **Ostracoda:** indeterminate forms, pyritized—three specimens **Diatomacea:** *Coscinodiscus* spp. Morphotype A-4 of Wall, 1975—one Morphotype D-1 of Wall, 1975 Morphotype D-2 of Wall, 1975 **Echinoidea:** spine fragments—rare **Crinoidea:** probable parts of arm articulation plates—rare **Age and Environment**. As for previous entry. The diatoms are identical to those reported from the correlative Clearwater Formation of northeastern Alberta.	C-97522/ 56.8-56.85
Moosebar, 66.6-66.7 m below top of borehole	**Foraminifera** (not common): *Saccammina*(?) sp.—two *Ammodiscus crenulatus* Chamney *Haplophragmoides* spp. *Uvigerinammina* sp.—one *Lingulina* sp., small—one *Globulina* sp.—one *Pyrulinoides*(?) sp.—one *Serovaina loetterlei* (Tappan)—two *Quadrimorphina albertensis* Mellon and Wall, small specimens **Diatomacea:** *Coscinodiscus* sp. Morphotype A-4 of Wall, 1975 Morphotype D-1 of Wall, 1975—one Morphotype E-2 of Wall, 1975—one	C-97522 66.6-66.7

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No./ Depth in metres
	Age and Environment. As for the previous two entries. The diatoms are identical to those recorded from the correlative Clearwater Formation of northeastern Alberta.	
Moosebar, 67.71 m below top of borehole	**Foraminifera:** *Ammodiscus* sp.-spp.—three specimens, one is probably *A. crenulatus* *Haplophragmoides* sp. A of Stelck and Wall, 1956 *H.* sp. *Ammobaculites* sp. *Gaudryina nanushukensis* Tappan *G. tailleuri* (Tappan) *Lenticulina macrodisca* (Reuss) *L.* sp. *Marginulinopsis collinsi* Mellon and Wall *Vaginulinopsis schloenbachi* (Reuss) *V.* spp.—two specimens *Dentalina* sp.—one chamber *Globulina lacrima canadensis* Mellon and Wall—one *Pyrulinoides* sp.—one *Discrobis norrisi* Mellon and Wall *Conorbina* sp. B of Stelck and Wall, 1956 *Serovaina loetterlei* (Tappan) *Gavelinella* sp. **Age and Environment**. As for other samples from this borehole.	C-97522/ 67.71

B. MACROFOSSILS

by J.A. Jeletzky

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
	Bullmoose Mountain, Section 80-1	
Chamberlain Member, Unit 62, 62.09 m below Moosebar	Indeterminate (presumably pectinid) pelecypod **Age and Correlation**. Cannot be dated on its only fossil. However, there is nothing in the collection from C-089303 to contradict its assignment to the Gething Formation, as proposed by the collector.	C-089303
Bullmoose Member, Unit 58, 92.08 m below Moosebar	*Pecten* (*Entolium*) cf. *irenense* McLean (mass occurrence, no other fossils noted) **Age and Correlation**. Generally speaking, the same as for lot number C-089301 and cannot be dated any closer. However, a mass occurrence of *Pecten* (*Entolium*) cf. *irenense* McLean combined with a total absence of *Buchia* is definitely suggestive of a post-Minnes Group (i.e. Aptian to Albian) age in the Peace River Basin. The mass occurrence of *Pecten* (*Entolium*) cf. *irenense* McLearn definitely indicates a marine (probably open marine) shelf environment.	C-089302
Bullmoose Member, Unit 54, 102.78 m below Moosebar	*Pecten* (*Entolium*) cf. *irenense* McLearn **Age and Correlation**. Lot C-089301 can only be dated as of a general Cretaceous age on the solitary *Pecten* (*Entolium*) cf. *irenense* McLearn. Though *P.* (*E.*) *irenense* is particularly common in the Aptian-Albian marine formations of the Canadian Western Interior Region, the comparison of the pectinid of lot C-089301 with this particular species does not necessarily suggest an Aptian-Albian age for this collection. There are a number of other longer ranging Cretaceous (and even Jurassic!) *Pecten* (*Entolium*) species [e.g. *P.* (*E.*) *orbicularis* (d'Orbigny)] which are for all practical purposes indistinguishable from *P.* (*E.*) *irenense* McLearn. Like all other pectinids, *P.* (*E.*) cf. *irenense* McLearn indicates a marine (possibly restricted) environment.	C-089301
	Utah Mines, WCC 82-8 borehole	
Gaylard Member, 13.9 m below top of borehole	Generically indeterminate unionid (i.e. nonmarine) pelecypods.	C-097508
Gaylard Member, 200.65 m below top of borehole	Generically indeterminate viviparid (i.e. nonmarine) gastropods. **Age and Correlation**. Lot C-097508 did not yield any short ranging macrofossils and so cannot be dated beyond an indication of its general post-Devonian age (on the presence of unionid pelecypods). Though poorly preserved, all pelecypods and gastropods of lot C-097508 are nonmarine types. The lot represents accordingly, a low energy, nonmarine (lacustrine topoludal) environment.	C-097508

C. PALYNOLOGY

by D.J. McIntyre

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
	Five Cabin Creek, Section 79-2	
Gething, Unit 30, 4 m above Cadomin	**Spores and pollen:** *Baculatisporites comaumensis* (Cookson) Potonié *Cicatricosisporites australiensis* (Cookson) Potonié *C. ludbrookii* Dettmann *C. potomacensis* Brenner *Gleicheniidites senonicus* Ross *Ischyosporites pseudoreticulatus* (Couper) Doring *Polycingulatisporites reduncus* (Bolkhovitina) Playford and Dettmann *Alisporites bilateralis* Rouse *Cerebropollenites mesozoicus* (Couper) Nilsson Spores are abundant and bisaccate pollen rare in this sample but preservation is poor and most grains are severely corroded.	C-89872 P2437-1
Gething, Unit 5, 19.6 m above Cadomin	The residue contains only woody tissue fragments. No spores were seen. **Comments**. The Thermal Alteration Index (TAI) of these samples is in the order of 3 and spores are brown in colour. The presence of *Cicatricosisporites potomacensis* suggests an age of Middle Albian or older in the Early Cretaceous.	C-89873 P2437-2
	Bullmoose Mountain, Section 80-1	
Chamberlain Member, Unit 72, 32 m below Moosebar	Woody tissue, with no identifiable spores.	C-89312 P2436-1
Chamberlain Member, Unit 70, 36 m below Moosebar	Woody tissue, with no identifiable spores. **Comments**. The TAI is in the range of 3 to 3+ indicating a high degree of maturation.	C-89312 P2436-2
	Dokken Creek, Section 79-3	
Gething, Unit 6, 7.6 m above Cadomin	Mainly dark coloured woody tissue fragments; only a few non-identifiable spores.	C-89883 P2438-1
Gething, Unit 20, 47.6 m above Cadomin	Mainly dark coloured woody tissue fragments; only a few non-identifiable spores. **Comments**. Spores are not identifiable and provide no information about age. TAI is 3 to 3+.	C-89884 P2438-2

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
	Utah BRI Dowling 78-4 borehole	
Gaylard Member, 3.8 m below Moosebar	**Spores and pollen:** *Osmundacidites wellmanii* Couper *Deltoidospora* sp. *Cicatricosisporites australiensis* (Cookson) Potonié *C. pseudotripartitus* (Bolkhovitina) Dettmann *Taxodiaceaepollenites hiatus* (Potonié) Kremp *Alisporites bilateralis* Rouse *A. grandis* (Cookson) Dettmann *Podocarpidites biformis* Rouse Bisaccate pollen, mainly *Alisporites*, is abundant but spores are rare and few are identifiable. Preservation is poor and most grains are corroded. There is abundant woody tissue.	C-72258 P2432-1
Gaylard Member, 64.28 m below Moosebar	Preservation is poor and spores and pollen are extremely rare; there are abundant small fragments of woody tissue.	C-72258 P2432-3
Gaylard Member, 73.18 m below Moosebar	**Spores and Pollen:** *Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann *Deltoidospora* sp. *Cicatricosisporites australiensis* (Cookson) Potonié *C. exilioides* (Maljavkina) Bolkhovitina *Contignisporites glebulentus* Dettmann *Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann *Gleicheniidites senonicus* Ross *Ischyosporites pseudoreticulatus* (Couper) Doring *Osmundacidites wellmanii* Couper *Alisporites bilateralis* Rouse *A. grandis* (Cookson) Dettmann *Podocarpidites canadensis* Pocock *Taxodiaceaepollenites hiatus* (Potonié) Kremp *Cerebropollenites mesozoicus* (Couper) Nilsson Bisaccate pollen, mainly *Alisporites*, is abundant but spores are relatively rare. Preservation is poor and most grains are corroded. Woody tissue fragments are abundant.	C-72258 P2432-5
Gaylard Member, 95.81 m below Moosebar	**Spores:** *Cicatricosisporties australiensis* (Cookson) Potonié *C. potomacensis* Brenner *Contignisporites glebulentus* Dettmann *Gleicheniidites senonicus* Ross *Ischyosporites pseudoreticulatus* (Couper) Doring *Osmundacidites wellmanii* Couper *Lycopodiumsporites austroclavatidites* (Cookson) Potonié *Polycingulatisporites reduncus* (Bolkhovitina) Playford and Dettman *Trilobosporites marylandensis* Brenner	C-72258 P2432-7

Formation or member, unit, depth/position	**Location, Fauna, Age and Environment**	**GSC Loc. No.**
	Bisaccate pollen, mainly *Alisporites* spp., is abundant but spores are relatively rare. There is abundant tissue, both woody type and leaf epidermal cells. **Comments (Utah BRI Dowling 78-4)**. Preservation of spores and pollen in the samples examined is generally poor, most are corroded to some extent, and many are not identifiable and have probably been somewhat oxidized during or shortly after deposition. The nature of the organic residue, abundant tissue, few spores and the absence of dinoflagellates indicate deposition in a nonmarine environment subject to a rapid influx of land derived material. Spores and pollen in the samples are brown to reddish brown with a Thermal Alteration Index (TAI) in the 3- to 3 range which agrees with the Ro values of 0.98-1.38, and indicates that the degree of maturation is in the mature range. The sparse microfloras identified indicate that the age is Early Cretaceous and not younger than Middle Albian, based on the presence of *Foraminisporis asymmetricus*, and *Contignisporites glebulentus*, which are not known above this stage.	
	Norcen, Pine Pass 79-1 borehole	
Gaylard Member, 94.87-95.25 m below Moosebar	**Spores and Pollen:** *Aequitriradites spinulosus* (Cookson and Dettmann) Cookson and Dettmann *Baculatisporites comaumensis* (Cookson) Potonié *Cicatricosisporites australiensis* (Cookson) Potonié *C. annulatus* Archangelsky and Gamerro *C. exilioides* (Maljavkina) Bolkhovitina *Contignisporites glebulentus* Dettmann *Deltoidospora* sp. *Dictyotriletes granulatus* Pocock *Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann *F. wonthaggiensis* (Cookson and Dettmann) Dettmann *Gleicheniidites senonicus* Ross *Trilobosporites perverulentus* (Verbitskaya) Dettmann *Microreticulatisporites uniformis* Singh *Alisporites bilateralis* Rouse *A. grandis* (Cookson) Dettmann *Cerebropollenites mesozoicus* (Couper) Nilsson *Podocarpidites biformis* Rouse Bisaccate pollen is rare but spores are common, especially *Cicatricosisporites* spp., and are well preserved.	C-89309 P2435-3
Gaylard Member, 124.52-128.53 m below Moosebar	This sample yielded only a sparse residue of woody fragments. No spores or pollen were seen. **Comments**. The presence of *Microreticulatisporites uniformis* and *Contignisporites glebulentus* indicate an Aptian to Middle Albian age. The spores are brown and the TAI is 3- to 3, indicating a high degree of maturation.	C-89309 P2435-4

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
	BP 53 borehole	
Bullmoose Member, 110.37 m below Moosebar	Recovery very sparse; rare bisaccate pollen grains (mostly fragmented); abundant woody debris.	C-72261 P2571-1
Bullmoose Member, 170.94 m below Moosebar	Recovery sparse; common bisaccate pollen grains (some complete) and spore fragments. **Dinoflagellates:** *Canningia* sp. *Chlamydophorella nyei* Cookson and Eisenack *Cyclonephelium distinctum* Deflandre and Cookson *Fromea amphora* Cookson and Eisenack *Gonyaulacysta* sp. *Odontochitina operculata* (Wetzel) Deflandre and Cookson *Spinidinium* sp. cf. *S. vestitum* Brideaux Dinoflagellates are corroded and severely carbonized. **Comments (BP 53).** The vitrinite reflectance of the interval from which these BP 53 samples were taken is about 1.60. Both samples contain a diverse assemblage of foraminifers, including calcareous species, thereby indicating a marine depositional environment.	C-72261 P2571-2
	Pacific MDD 77-3 borehole	
Chamberlain Member, 30.19 m below Moosebar	**Spores and Pollen:** A few severely corroded spores and pollen were seen but not identified. **Dinoflagellates:** *Dingodinium cerviculum* Cookson and Eisenack *Chlamydophorella trabeculosa* (Gocht) Davey *Muderongia asymmetrica* Brideaux *Odontochitina operculata* (O. Wetzel) Deflandre *Palaeoperidinium cretaceum* Pocock emend. Davey These dinoflagellates are extremely poorly preserved. Many other probable dinoflagellates were not identifiable even to the generic level. Fragments of woody tissue are abundant.	C-72263 P2434-1

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
Chamberlain Member, 43.49 m below Moosebar	The spore *Microreticulatisporites uniformis* Singh is common but other spores are rare and not identifiable. The residue consists of woody tissue. **Comments (Pacific MDD 77-3).** The few spores seen are brown and have a TAI of 3, which agrees with the Ro values of 1.16-1.42. The presence of *Microreticulatisporites uniformis* and *Muderongia asymmetrica* indicates that the age is Aptian to Middle Albian. The presence of dinoflagellates at 47.85 m indicates deposition in a marine, probably nearshore environment.	C-72263 P2434-2

Denison Belcourt 78-11 borehole

Formation or member, unit, depth/position	Location, Fauna, Age and Environment	GSC Loc. No.
Gething, 14.14 m below Moosebar	A few corroded spores, not identified, and rare fragments of bisaccate pollen were seen along with woody tissue fragments.	C-72262
Gething, 21.03 m below Moosebar	**Spores:** *Cicatricosisporites australiensis* (Cookson) Potonié *Deltoidospora* sp. *Gleicheniidites senonicus* Ross *Ischyosporites pseudoreticulatus* (Couper) Doring *Osmundacidites wellmanii* Couper The residue is mainly woody tissue fragments. No bisaccates were seen. **Comments (Denison Belcourt 78-11).** The few spores seen are poorly preserved and provide no evidence of age other than Early Cretaceous. The spores are brown with a TAI of 3 to 3+, indicating a high degree of maturation. The TAI is in agreement with the Ro values of 1.35-1.46.	P2433-2

General Remarks

The samples examined yield little significant information about age, other than Early Cretaceous, Aptian to Middle Albian in a few instances.

All samples have reached a high degree of thermal alteration and preservation of palynomorphs is generally poor. Little can be said about the environment of deposition except that most are consistent with a nonmarine environment.

The main reason for the scarcity of pollen and spores in most samples is probably the dilution factor, i.e., few grains are deposited relative to the large amount of woody tissue. This problem is then compounded by poor preservation, probably oxidation before or shortly after deposition, and thermal alteration of the assemblages recorded.

APPENDIX 3

TYPE AND REFERENCE SECTIONS

A. TYPE SECTION OF THE BULLMOOSE MEMBER AND REFERENCE SECTIONS OF THE GAYLARD AND CHAMBERLAIN MEMBERS OF THE GETHING FORMATION

Location: Section measured in small intermittent stream gully and cirque basin on the south side of Bullmoose Mountain; topographic map of Bullmoose Creek, NTS 93 P/3; UTM coordinates 596300E, 6116500N. Access to area is via Tech Corporation coal haulage road to Bullmoose Mine, then proceeding northwestward along a British Petroleum gas well service road adjacent to a small creek.

Unit No.	Description	Unit Thickness (m)	Cumulative Thickness Above Base (m)
	CHAMBERLAIN MEMBER (76.6 m)		
75	**Sandstone:** quartzose, pyritiferous near base; fine to medium grained; medium dark grey, weathering medium light grey; medium-scale trough crossbedding; wood moulds and casts in parts; well indurated; abruptly overlain by thin, dark grey glauconitic carbonaceous sandstone of the Moosebar Formation; resistant	4.9	296.8
74	**Sandstone:** quartzose, slightly calcareous; fine to medium grained with coarsening-upward profile; medium dark grey, weathering brownish grey; thick bedded; medium- to large-scale, shallow-troughed, festoon to possible swaley crossbedding; scattered ironstone concretions; parallel lamination in part; erosional contact with underlying coal seam; resistant to slightly recessive	24.2	291.9
73	**Coal:** blocky and vitreous in part; thin shale partings near base; recessive	0.4	267.7
72	**Mudstone** to **siltstone**, and minor **coal:** latter forming 12 cm bed at base pinching out along cliff face; mudstone-siltstone dark grey with lenticular to rippled sandstone laminae throughout; small horizontal burrows in part; plant fragments throughout; recessive	3.8	267.3
71	**Sandstone:** quartzose, slightly carbonaceous-argillaceous; very silty in upper half; planar and ripple lamination; abundant plant fragments in upper 0.3 m; slightly recessive to recessive	1.0	263.5
70	**Coal (Chamberlain Seam):** blocky with vitreous bands; thin shale partings in upper 0.6 m; recessive	1.8	262.5
69	**Sandstone** and **siltstone:** interbedded and interlaminated; quartzose, carbonaceous- argillaceous; medium dark grey, weathering same; thin bedded; ripple lamination; becomes increasingly more silty toward top; slightly recessive	3.0	260.7
68	**Sandstone:** quartzose; very fine to fine grained; dark grey, weathering same; very silty in part; thin bedded; ripple lamination; weathers platy; slightly recessive	3.0	257.7
67	**Sandstone:** quartzose, medium grained; medium grey, weathering light grey; shallow-troughed, festoon crossbeds; displays bleached character; slightly recessive to resistant	1.2	254.7

Unit No.	Description	Unit Thickness (m)	Cumulative Thickness Above Base (m)
66	**Sandstone:** quartzose, calcareous in part; fine to medium grained; medium grey, weathering brownish grey; medium to thin bedded; medium-scale, shallow-troughed, festoon to possible swaley crossbedding; planar to slightly inclined laminae in part; weathers platy; resistant	12.2	253.5
65	Covered interval: unit across valley consists of alternating resistant and recessive weathering couplets of siltstone and sandstone; sandstone is ripple laminated; recessive	3.2	241.3
64	**Sandstone:** quartzose, slightly calcareous; fine to medium grained, displaying coarsening-upward profile; medium grey, weathering greyish brown; few thin siltstone interbeds in lower 1.5 m; medium- to large-scale, festoon to possible swaley crossbedding; thick to medium bedded; pectinid bivalves 4 m above base; angular mudstone rip-up clasts in lower 1.5 m; scattered wood fragments on parting planes in part; gradational contact with underlying Bullmoose Member; resistant	17.9	238.1
	BULLMOOSE MEMBER (61.4 m)		
63	**Sandstone** and **siltstone** interbedded **Sandstone:** quartzose, calcareous; fine to very fine grained; medium grey, weathering orange-brown **Siltstone:** sandy, carbonaceous-argillaceous; dark grey with lighter grey wavy to ripple laminae Sandstone beds increase in thickness and frequency toward top; hummocky crossbedding in thicker beds; slightly recessive to resistant	5.2	220.2
62	**Siltstone**: with minor, very fine grained **sandstone** interbeds; calcareous; medium dark to medium grey, weathering orange-brown to yellow-brown; sandstone displays hummocky crossbeds; sandstone beds increase in thickness and frequency toward top; vertical burrows and bioturbation mottling in siltstone; no obvious plant matter; scattered bivalves; slightly recessive	4.7	215.0
61	**Mudstone** to **siltstone:** slightly calcareous, carbonaceous-argillaceous; dark grey, weathering same; burrows and bioturbation mottling; Foraminifera collection C-89312i; recessive	4.2	210.3
60	**Siltstone** to **sandstone:** quartzose, argillaceous, slightly calcareous; thin to medium bedded; shallow-troughed, festoon crossbeds; parallel to ripple lamination; pyrite filled vugs; well preserved bivalves, collection C-089302; slightly recessive to resistant	0.7	206.1
59	**Siltstone** to **mudstone:** with very fine grained, rippled, sandstone laminae; laminae weather orange-brown to light grey; burrows and bioturbation mottling throughout; Foraminifera collection C-89312h; recessive	3.4	205.4
58	**Siltstone** to **sandstone:** quartzose, carbonaceous-argillaceous, calcareous; sandstone very fine grained, in beds up to 25 cm; fine parallel to ripple lamination with latter in upper half of beds; vertical and horizontal burrows throughout; sandstone displays hummocky crossbeds; slightly recessive	3.0	202.0

Unit No.	Description	Unit Thickness (m)	Cumulative Thickness Above Base (m)
57	**Siltstone** to **mudstone:** siltstone-mudstone as above; ironstone concretionary bands; vertical burrow traces in upper half; 0.3 m of orange-brown weathering, 0.3 m calcareous sandstone at base; recessive	3.5	199.0
56	**Siltstone:** quartzose, very carbonaceous-argillaceous, slightly calcareous; dark grey, weathering same; horizontal burrows and bioturbation mottling; marine bivalve collection C-089301; Foraminifera collection C-89312g; recessive	1.7	195.5
55	**Siltstone** to **mudstone:** slightly calcareous, carbonaceous-argillaceous; dark grey, weathering same; no plant matter; Foraminifera collection C-89312f from near base; recessive	5.4	193.8
54	**Sandstone:** quartzose, calcareous, glauconitic; fine to coarse grained to gritty in part; medium dark grey, weathering greyish brown to conspicuous orange-brown; glauconite concentrated in upper 1 m; large orange-brown weathering ironstone concretions up to 20 cm in diameter in upper 1 m; unit coarsens upward; shallow-troughed, festoon to possible swaley crossbeds in lower 2 m; resistant	3.8	188.4
53	**Siltstone** and minor **sandstone** **Siltstone:** sandy, carbonaceous-argillaceous; dark grey **Sandstone:** calcareous, fine to medium grained and ripple laminated; occurs as thin beds up to 0.3 m thick Unit is slightly recessive	3.2	184.6
52	**Siltstone:** calcareous; medium dark grey, weathering yellowish grey; small pyrite crystals throughout; dense and well indurated; slightly recessive to resistant	1.1	181.4
51	**Sandstone** and **siltstone:** interbedded and interlaminated; quartzose, calcareous; wavy to lenticular thin sandstone beds; ripple to parallel lamination; burrow traces; sandstone beds and laminae increase upward; slightly recessive	7.7	180.3
50	**Siltstone** to **mudstone:** calcareous; dark grey, weathering same to greyish brown; wavy to lenticular bedding; siltstone increases upward; burrows and bioturbation mottling; no conspicuous plant matter; recessive	9.3	172.6
49	**Siltstone** to **mudstone:** slightly calcareous; burrow traces; ripple lamination; wavy to lenticular bedding; recessive; unit has an abrupt contact with the underlying Gaylard Member.	4.5	163.3

GAYLARD MEMBER
(158.8 m)

Unit No.	Description	Unit Thickness (m)	Cumulative Thickness Above Base (m)
48	**Sandstone:** quartzose, slightly calcareous in lower half; fine grained; medium dark grey, weathering orange-brown; thick bedded, but weathers platy; medium- to large-scale, shallow-troughed, festoon or possible swaley crossbedding; ripple lamination in upper half; unit capped by 0.9 m of light to medium grey weathering sandstone displaying bleached appearance, which forms lithological marker in the basin; unit has an abrupt contact with underlying unit; resistant	6.6	158.8

Unit No.	Description	Unit Thickness (m)	Cumulative Thickness Above Base (m)
47	**Siltstone** to **mudstone** and **sandstone:** quartzose, calcareous in part; sandstone occurs as thin, wavy to lenticular interbeds displaying well developed ripple lamination; sandstone beds and laminae increase upward; siltstone-mudstone is dark grey with small horizontal burrow traces; orange-weathering ironstone concretions in part; Foraminifera collection C-89312e from near base; slightly recessive	5.1	152.2
46	**Mudstone** and minor **coal:** latter as two seams 0.3 m and 0.2 m thick, occurring 1.2 and 2.3 m above the base respectively; mudstone is dark grey, with plant fragments and vitreous coal lenticles throughout; recessive	2.6	147.1
45	**Siltstone** and lesser **sandstone** and **mudstone:** interbedded and interlaminated; calcareous; sandstone is fine to medium grained, with ripple lamination and weathers orange-brown, forming distinct beds up to 0.3 m thick; siltstone is sandy and dark grey, weathering same; small burrow traces; small-scale ripple cross-stratification; slightly recessive	6.2	144.5
44	**Sandstone:** quartzose, calcareous; fine grained; parallel and ripple lamination in part; small-scale, festoon crossbedding; abrupt contact with underlying unit; resistant	1.8	138.3
43	Covered interval: with partial exposure in lower 1.5 m consisting of dark grey, sandy, laminated siltstone; dark grey mudstone to shale at base with large concentration of plant matter; recessive	4.8	136.5
42	**Sandstone:** quartzose, carbonaceous-argillaceous; medium dark grey, weathering greyish brown; fine parallel and ripple lamination; slightly recessive	0.7	131.7
41	**Mudstone** and **siltstone:** sandy in upper 0.3 m; dark grey, weathering same; subconchoidal fracture in part; distorted and ripple lamination in upper half; recessive	4.1	131.0
40	**Siltstone:** quartzose, carbonaceous-argillaceous; well developed sandstone ripple laminae; orange-brown weathering ironstone bands; slightly recessive to recessive	2.0	126.9
39	Covered interval: sporadic exposure in lower 3 m of dark grey sandy siltstone; sporadic exposure of dark grey mudstone in remainder of unit; recessive	11.9	124.9
38	**Sandstone:** quartzose, calcareous; very fine grained; medium grey, weathering orange-brown; well developed ripple lamination; slightly recessive	0.4	113.0
37	**Siltstone** to **mudstone:** carbonaceous-argillaceous; dark grey, weathering same; abundant concentration of plant fragments; orange-brown ironstone concretions; Foraminifera collection C-89312c; recessive	1.8	112.6
36	**Siltstone:** quartzose, very calcareous; medium dark grey, weathering orange-brown; sandy ripple laminae; small festoon crossbed in upper 0.6 m; vertical rootlets in upper 0.3 m; unit coarsens upward; slightly recessive	1.2	110.8
35	**Mudstone** to **shale:** dark grey, weathering same; high concentration of plant matter; vitreous coal lenticles; possible thin coal seam; partly talus covered; recessive	4.3	109.6

Unit No.	Description	Unit Thickness (m)	Cumulative Thickness Above Base (m)
34	**Sandstone:** quartzose, calcareous; very fine grained; medium dark grey, weathering orange-brown; ripple lamination; slightly recessive	0.4	105.3
33	**Mudstone** to **shale** and minor **coal:** one coal seam is 0.2 m thick, 1.2 m above base; another seam is 0.7 m thick, 3.7 m above base; mudstone-shale is dark grey with high concentration of plant matter; interval partly talus covered; recessive	7.5	104.9
32	**Siltstone** to **sandstone:** medium to brownish grey, weathering orange-brown; vertical burrow traces; fine ripple lamination near top; scattered plant fragments; ironstone concretionary bands; slightly recessive	0.6	97.4
31	**Siltstone** to **mudstone** and minor **coal:** dark grey, weathering same; scattered plant fragments; the coal occurs as a 7.6 cm thick seam, 1.5 m above base; interval partly talus covered; recessive	6.0	96.8
30	**Sandstone:** quartzose; very fine to fine grained; medium grey, weathering same; thin siltstone bed in centre; ripple lamination in part; vertical burrow traces; plant rootlets in upper 15 cm; unit very well indurated and siliceous; resistant to slightly recessive	0.8	90.8
29	**Siltstone** to **mudstone:** carbonaceous-argillaceous; dark grey, weathering same; fine ripple lamination; scattered plant fragments; recessive	1.9	90.0
28	**Sandstone:** quartzose; medium to fine grained with fining-upward profile; medium grey, weathering brownish grey; dark grey mudstone rip-up clasts near base; medium-scale, shallow-troughed, festoon crossbedding; parallel and ripple lamination in upper 0.3 m; wood moulds and casts at top and bottom; resistant	2.2	88.1
27	Covered interval: minor mudstone exposed at base; Foraminifera collection C-89312b; recessive	2.3	85.9
26	**Siltstone** and **sandstone** **Siltstone:** calcareous; very carbonaceous-argillaceous; scattered plant matter **Sandstone:** calcareous; very fine to fine grained; ripple laminated Talus covered except for upper and lower 0.5 m; slightly recessive to recessive	2.9	83.6
25	**Mudstone** to **shale:** dark grey, weathering same; possible thin seams of coal; high concentration of plant matter; partly talus covered; recessive	5.6	80.7
24	**Sandstone:** quartzose, calcareous; fine to very fine grained; medium dark grey, weathering orange-brown; small-scale festoon crossbeds and ripple lamination throughout; resistant to slightly recessive	1.3	75.1
23	**Siltstone, sandstone** and **mudstone:** interbedded and interlaminated; unit mainly dark grey, carbonaceous-argillaceous siltstone; sandstone is thin bedded with well developed ripple lamination; scattered plant fragments throughout; uppermost 0.3 m consists of light grey weathering siliceous siltstone that is dark grey on fresh surface; this bed resembles a paleosol or ganister facies; recessive to slightly recessive	1.6	73.8
22	**Mudstone** to **shale:** carbonaceous, with plant fragments; dark grey, weathering same; partly talus covered; recessive	3.6	72.2

Unit No.	Description	Unit Thickness (m)	Cumulative Thickness Above Base (m)
21	**Sandstone:** quartzose, carbonaceous-argillaceous; medium dark grey, weathering brownish grey; very fine grained, silty in part; ripple lamination; vertical rootlets in upper 10 cm; plant fragments throughout; resistant to slightly recessive	0.5	68.6
20	**Siltstone:** siliceous, carbonaceous; dark grey, weathering very light grey; scattered plant fragments; contain possible rootlets; may represent a paleosol or ganister facies; resistant to slightly recessive	0.6	68.1
19	**Sandstone** and **siltstone** (interbedded): quartzose; sandstone very fine grained; medium dark grey, weathering light grey; siltstone is carbonaceous-argillaceous; bedding wavy to lenticular and weathers as resistant-recessive couplets; rootlets in upper 0.6 m; slightly recessive	3.5	67.5
18	**Sandstone:** quartzose; fine to medium grained; medium dark grey, weathering brownish grey; medium bedded; well developed ripple lamination; wood moulds and casts at base; plant fragments on parting surfaces; resistant	1.6	64.0
17	**Mudstone** to **shale:** vitreous coal lenticles throughout; high concentration of comminuted plant matter; recessive	0.2	62.4
16	**Coal:** blocky; dull to vitreous lustre; well developed cleats; slightly recessive to recessive	0.7	62.2
15	**Mudstone** to **shale** and minor **coal:** dark grey with high concentration of plant matter; fissile in part; coal occurs as thin beds 0.06 m and 0.09 m thick, 0.09 and 1.5 m above the base respectively; seams blocky and vitreous; recessive	1.9	61.5
14	**Sandstone:** quartzose, carbonaceous-argillaceous; very silty and may in part be classed as sandy siltstone; medium dark to dark grey, weathering same; unit fines upward; ripple lamination and vertical rootlets; slightly recessive	1.3	59.6
13	**Mudstone** to **shale:** carbonaceous; dark grey, weathering same; high concentration of plant matter; thin ironstone bands near top; recessive	0.5	58.3
12	**Sandstone:** quartzose, slightly calcareous; medium to fine grained with fining-upward profile; medium dark grey, weathering orange-brown; angular, dark grey mudstone rip-up clasts near base; ironstone concentrations in places; medium-scale, shallow-troughed, festoon crossbedding; climbing ripple lamination in upper 1.5 m; upper 0.3 m is very silty; scattered plant matter in fine grained facies; resistant	3.4	57.8
11	**Mudstone** and **siltstone** to **sandstone:** mudstone-siltstone is dark grey, weathering same; occasional thin ironstone concretionary beds; plant fragments not common; sandstone is ripple laminated, occupying upper 0.6 m; recessive	1.8	54.4
10	**Siltstone:** quartzose, carbonaceous-argillaceous; very sandy; contains thin, dark grey mudstone partings; ripple lamination; slightly recessive to recessive	1.9	52.6
9	**Mudstone:** carbonaceous; dark grey, weathering same; scattered plant fragments; recessive	2.9	50.7

Unit No.	Description	Unit Thickness (m)	Cumulative Thickness Above Base (m)
8	**Siltstone:** quartzose, carbonaceous-argillaceous; dark grey, weathering same; rootlets near base; scattered plant fragments throughout; unit partly talus covered; slightly recessive to recessive	3.2	47.8
7	**Sandstone:** quartzose; fine grained; medium dark grey, weathering light grey to buff; medium bedded; unit fines upward; parallel lamination; resistant	1.3	44.6
6	**Sandstone:** quartzose, slightly argillaceous near top; very fine to medium grained, becoming finer grained upward; medium grey, weathering same to brownish grey; medium-scale festoon crossbeds in lower half; ripple lamination in finer grained facies; convolute laminae near base; wood moulds and casts on some parting surfaces; unit has abrupt contact with underlying conglomerate; slightly recessive to recessive	3.6	43.3
5	**Conglomerate** and minor **sandstone:** poorly sorted conglomerate composed mainly of clast supported, well rounded, dark and light grey chert, quartzite, and siliceous argillite pebbles up to 10 cm in diameter; large-scale festoon crossbeds; sandstone forms the upper 0.3 m and is medium grained with floating pebbles; unit underlain by large, mainly talus covered interval; resistant	12.5	39.7
	Note: underlying lithology and thickness values from Stott, 1973, p. 222		
4	Covered interval: with sporadic exposures of platy sandstone; recessive	7.0	27.2
3	Covered interval: with evidence of coal in talus; recessive	4.3	20.2
2	Covered interval: sandy siltstone exposed at base, and mudstone and platy laminated sandstone at top; recessive	3.7	15.9
1	Covered interval: unit thickness approximate with base forming contact with Cadomin Formation.	12.2	12.2

B. TYPE SECTION OF THE CHAMBERLAIN MEMBER OF THE GETHING FORMATION

Location: Coal exploration borehole BP 53, BP Coal Canada; topographic map of Sukunka River, NTS 93 P/4; UTM coordinates 588170E; 6120861N. Cored interval may be examined at core and sample storage facilities of the British Columbia Ministry of Energy, Mines and Petroleum Resources, Charlie Lake, British Columbia. Cored interval 38.75 to 136.41 m.

Unit No.	Description	Unit Thickness (m)	Depth Below Top (m)
	CHAMBERLAIN MEMBER (96.35 m)		
1	**Sandstone:** quartzose; light grey; fine to coarse grained to conglomeratic; conglomeratic bed is 4 cm thick, occurs 27 cm below top, and consists of light and dark grey chert and quartzite pebbles in coarse grained sandstone matrix; horizontal burrow traces near base, rare dark grey mudstone rip-up clasts; coarse planar lamination; forms erosional contact with underlying unit; unit overlain by dark grey glauconitic sandstone of basal Moosebar Formation	1.15	38.75
2	**Coal** and minor **mudstone** (removed from core by BP Coal): Bird Seam; mudstone is dark grey with abundant plant matter, forming upper 6 cm	1.07	39.90
3	**Mudstone:** carbonaceous; dark grey; scattered plant fragments; subconchoidal fracture	0.23	40.97
4	**Sandstone:** quartzose, calcareous; medium to coarse grained, with grit bands near base composed of well rounded, dark grey, chert granules up to 3 mm in diameter; light grey *Macaronichnus* burrow traces near top; planar to low-angle lamination; medium- to small-scale crossbedding; occasional coalspars near top; unit forms part of coarsening-upward sequence with underlying unit	6.63	41.20
5	**Sandstone:** quartzose, calcareous; fine grained; light grey; fine planar to slightly inclined lamination throughout; scattered coalspars; *Paleophycus* burrow traces in part; abrupt contact with underlying unit	11.49	47.83
6	**Mudstone** and **sandstone** (interbedded and interlaminated) **Mudstone:** slightly calcareous; dark grey. **Sandstone:** calcareous; very fine grained; well developed ripple lamination. Wavy and lenticular bedding; well developed *Planolites*-like burrow traces, rare small pyritized burrow traces; possible *Helminthopsis*-like burrow in mudstone; rare bivalves; abrupt contact with underlying unit	4.98	59.32
7	**Sandstone:** quartzose, calcareous; medium to fine grained with coarsening-upward profile; light grey; planar to low-angle lamination; occasional coalspars near top; *Paleophycus*-like burrow trace	0.86	64.30
8	**Sandstone, siltstone** and minor **mudstone** (interbedded and interlaminated) **Sandstone:** quartzose, calcareous; very fine grained; forms predominant lithology; well developed ripple and some distorted lamination; small burrow traces, some filled with pyrite. **Siltstone-mudstone:** calcareous, dark grey; rare plant fragments; siltstone-mudstone increases toward base; microfossil analysis C-72261	2.87	65.16

Unit No.	Description	Unit Thickness (m)	Depth Below Top (m)
9	**Sandstone:** quartzose, calcareous; fine to coarse grained with fining-upward profile; light to medium grey; small-scale crossbedding; ripple lamination common in finer grained facies; some distorted laminae; conspicuous coal-spars in lower third; erosional contact with underlying unit	9.40	68.03
10	**Coal** (removed from core by BP Coal)	0.14	77.43
11	**Mudstone** (removed from core by BP Coal): carbonaceous with vitreous coal lenticles	0.06	77.57
12	**Mudstone** to **siltstone** (removed from core by BP Coal): carbonaceous with vitreous coal bands	0.13	77.63
13	**Mudstone** (removed from core by BP Coal): dark grey, carbonaceous	0.04	77.76
14	**Coal** (removed from core by BP Coal): upper Chamberlain or Skeeter Seam	1.56	77.80
15	**Siltstone** (removed from core by BP Coal): argillaceous; medium to dark grey; dark grey, thin mudstone bands and laminae; abundant plant fragments	0.27	79.36
16	**Mudstone** (removed from core by BP Coal): carbonaceous; dark grey; scattered plant fragments	0.06	79.63
17	**Coal** (removed from core by BP Coal): unit forms base of upper Chamberlain, or Skeeter Seam, interval	0.53	79.69
18	**Mudstone** to **siltstone:** interbedded and interlaminated; carbonaceous; siltstone is slightly calcareous; dark grey; abundant plant fragments but decreasing in concentration toward base	1.31	80.22
19	**Sandstone, siltstone** and **mudstone** (interbedded and interlaminated) **Sandstone:** quartzose, calcareous; very fine grained; well developed thin, wavy to lenticular beds; well developed ripple lamination; some distorted laminae. **Siltstone** and **mudstone:** dark grey; carbonaceous and slightly calcareous; concentration of siltstone and mudstone increases toward base; small burrow traces	1.70	81.53
20	**Mudstone:** carbonaceous; very silty in part; dark grey; rare pyrite grains or crystals; microfossils (C-72261)	2.63	83.23
21	**Mudstone** (removed from core by BP Coal): carbonaceous; dark grey	0.09	85.86
22	**Coal** (removed from core by BP Coal): lower Chamberlain Seam	1.95	85.95
23	**Sandstone:** quartzose, medium to coarse grained; light to medium grey; rare coalspars and dark grey mudstone rip-up clasts in upper 2 m; planar to low-angle lamination; small-scale, festoon crossbedding in part; *Macaronichnus* burrows in lower half; unit forms part of coarsening-upward facies with underlying unit	12.66	87.90
24	**Sandstone:** quartzose, calcareous; medium to fine grained; light grey; well developed crossbedding; planar lamination in parts; *Paleophycus* burrow traces in upper 10 cm; angular, dark grey mudstone rip-up clasts 15 cm above base; unit displays coarsening-upward profile; abrupt erosional contact with underlying unit	9.44	100.56

Unit No.	Description	Unit Thickness (m)	Depth Below Top (m)
25	**Sandstone, siltstone** and **mudstone** (interbedded and interlaminated) **Sandstone:** quartzose, calcareous; very fine grained; medium light grey; forms thin, ripple laminated, wavy to lenticular beds. **Siltstone** and **mudstone:** carbonaceous and slightly calcareous; dark grey; scattered pyrite grains and/or crystals in mudstone. Unit forms distinct alternation of lighter and darker grey beds and laminae; *Paleophycus* burrow traces in some thicker sandstone beds; well developed syneresis cracks in parts; gradational with underlying unit	2.88	110.00
26	**Siltstone** to **sandstone** and **mudstone** (interbedded and interlaminated) **Siltstone-sandstone:** quartzose, calcareous; medium to light grey; forms thin, ripple laminated, wavy to lenticular beds; beds commonly graded, with sharp erosional bases. **Mudstone:** calcareous, carbonaceous; dark grey. Bioturbation mottling and distinct sand-filled burrow traces; pelecypod shell fragments, a few plant fragments, Foraminifera collection (C-72261)	3.12	112.88
27	**Sandstone:** quartzose, calcareous, traces of glauconite; medium to coarse grained to gritty; black chert and pyritized mudstone grains common; mudstone matrix common; becomes coarser grained toward base; abrupt contact with underlying unit	0.09	116.00
28	**Sandstone:** quartzose, calcareous; fine to very fine grained, becoming finer grained toward base; light grey; medium- to large-scale crossbedding; thin, dark grey mudstone band 4.7 m above base; 8 cm thick mudchip conglomerate, 1.7 m above base; *Paleophycus* burrows in upper 0.7 m; gradational contact with underlying transitional facies of the Bullmoose Member	19.01	116.09

MAPS
NOT
FILMED

CARTES
OMISES